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ABSTRACT

An overview is presented of the planning information needs of an institution of higher learning, and an approach to the collection of appropriate activity and facility information. Emphasis is given to space management and activities data with regard to facilities planning effectiveness. A computer program for evaluation of alternate building programs is described; input data requirements are set forth and related to the activities and facilities data described. (FS)

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INFORMATION NEEDS:

for planning physical facilities in colleges and universities

Overview

July 1969

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"Despite our limited behavioral knowledge, the college must recognize that even its instructional goals cannot be effectively achieved unless it assumes some responsibility for facilitating the development of the total human personality. A student is not a passive digester of knowledge elegantly arranged for him by his superior artists of curriculum design. He listens, reads, thinks, studies, and writes at the same time that he feels, worries, hopes, loves, and hates. He engages in all these activities not as an isolated individual but as a member of overlapping communities which greatly influence his reactions to the classroom experience. To teach the subject matter and ignore the realities of the student's life and the social systems of the colleges is hopelessly naive."

The Student in Higher Education. The Committee on The Student in Higher Education. (New Haven, Conn.: The Hazen Foundation, Jan. 1968), p. 6.

FOREWORD

The information presented in this series of four volumes was developed under the terms of a research project funded jointly by Educational Facilities Laboratories, Inc., and Duke University in May of 1966. The project drew to a close with a seminar presented to selected Institutional Research representatives of North Carolina institutions March 10-11, 1969. Attendees were introduced to the material described herein.

The purpose of the project has been to develop techniques which will assist institutions of higher education in dealing with the problems of physical facilities planning. In particular, the project staff set out

- To define a campus planning process,
- To identify information useful in the planning process and show how it is most usefully organized,
- To develop an economical method of testing the desirability of alternative building programs prior to deciding upon one.

The work has been divided among four primary tasks

- Design, creation and use of a space inventory file
- Development of techniques for collecting useful quantitative data on the activities the institution is obliged to house
- Development of a computer-driven mathematical model simulating an institution's use of its physical facilities
- Investigation of a feasible method of rationing building space to competing user programs by way of budgeted "prices" or rents.

This division of effort has also provided the divisions of the final report. This first volume is devoted to an overview of the planning information needs of an institution of higher learning, and an approach to the collection of appropriate activity and facility information.[1] There are three companion volumes:

Volume 2 – Room Inventory: A Technique for Data Collection and Analysis

Volume 3 – Space-Demanding Activities: A Technique for Data Collection and Analysis

Volume 4 – Space Planning: A Technique for Evaluating Alternative Campus Building Programs

[1] Copies of these reports can be obtained from Educational Facilities Laboratories, 477 Madison Avenue, New York, New York 10022. Computer program listings and complete sample output are available through the EFL Library.

Acknowledgements

It would be impossible to list all the people whose work has gone into this project. At the risk of leaving out many names, the work of some individuals should be recognized. Of importance in conceiving the problem to be investigated and preliminary study of the uses of computers in planning, Philip Williams and Charles Thomsen of Caudill Rowlett Scott (CRS), should be mentioned. Phil has continued as a valuable critic and advisor. The work of Robert Mattox, also of CRS, has been central to the entire project. He provided the basis for our understanding of the campus planning process and developed and carried out the approach taken to the evaluator model, working with an idea originally provided by Robert Holz of Hewes, Holz and Willard of Winchester, Massachusetts. Also an important contributor to this model and to our concept of the facilities planning information base was Richard Willard of the same firm. Charles Sims, Programming and Systems Consultant, and Stephan Van Pelt, Systems Analyst of CRS, contributed extensively in the design and programming of the evaluator program.

For early support of our work at Duke we are indebted to John Dozier, then Business Manager, and for the continuing interest and useful commentary of Hamilton Hoyler, Coordinator of Institutional Data Processing. Fred Adair, then Assistant Registrar, designed the original student diary and gave valuable assistance in its initial administration. Bruce Anderson refined the diary format, particularly the questionnaire, and gave valuable advice on sample size and composition. Robert Chamberlin coordinated the collection and processing of data on the room inventory and student diary tasks. Of particular value have been the work and comments of two Duke students: Jeffery Lazarus who has written the room inventory system of computer programs and put together the relevant manual, and Judith King who has performed similar services for the student diary task. Their work was done while carrying a full academic work load as undergraduate juniors.

The valuable contribution to the project of Prof. John O. Blackburn, Chairman of the Department of Economics, is contained in the appendix on space pricing. The work of William Kirkland, who now manages Duke's Room Inventory Effort, and his crew of data gatherers was essential to the successful completion of the project. Special thanks should go to the three Duke undergraduates who ran the diary data collection organizations during the three tests of the instrument: Guy Solie (Spring 1967), Bill Clifton (Spring 1968) and Jim Ebron (Fall 1968). Another Duke student, Marvin Rose, undertook a research project on interfacility travel times, and thereby provided the project with valuable information.

We are indebted to Jonathan King and Alan Green, Vice President and Secretary respectively of EFL, for their encouragement and useful comments during the course of the project.

Walter Matherly — Principal Investigator
July 1969

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STATEMENT OF THE PROBLEM

As colleges and universities account for more and more of the national product of the US, the methods by which these institutions allocate their resources to particular programs become correspondingly more important. Specialized techniques for measuring and governing the effectiveness and efficiency of educational inputs are employed by institutional administrations in increasing numbers. It has even become respectable to speak of *resource productivity* in discussing instructional and research programs in higher education. Indeed, "The only choice left appears to be between (a) permitting the institutions to be evaluated and governed by confusion, or (b) launching a concerted effort to obtain measures by which we are willing to live and educating both ourselves and others in their proper usage. It is in the latter that colleges and universities will find rationality."[2]

The way an institution allots its resources to user programs can have a considerable effect on the productiveness of each unit of resource used. It is generally in budgeting, and in planning tied closely to budgets, that the act of resource allocation is accomplished. If budgets under-emphasize or ignore certain types of resource, too much of one type may be combined with too little of another for economical operation. Over time this allocation will almost certainly result in a level of services significantly lower than that possible with the same amount of money but different relative amounts of all types of resource. For example, if insufficient staff and students are on hand to use fully the equipment and buildings owned by an institution, new funds would be ill-spent on more physical facilities without first enlarging the staff or enrollment. In another situation, crowded facilities might make it unwise to add staff until additional building space could be erected. If the proportion of space to people and equipment is too low conditions are considered *crowded.* If the reverse is true, the institution is considered *understaffed* or *underequipped.* Clearly, wise plans for the use of funds and the services of sunk-cost facilities must take into account the current *mix,* or relative proportions of different resources available, as well as total amounts of all types.

As numbers of students and quantities of research change, adjustments in the total and relative amounts of each kind of resource used must be made if program quality and cost are to be maintained or improved. Such adjustments are best implemented by timely alterations in the plan by which the institution operates. Such a document merely anticipates future operations to the extent they can be estimated. The farther in the future we reach, the less precise and distinct our estimations are likely to become; but without them, decisions must be made in the dark, which may cost the institution dearly within a few years. The longer the anticipated life of a physical facility, the more costly can be current decisions which are made in ignorance. Plans may appear in many guises, eg, budgets, long range goal statements, architects' drawings, trustee policy statements, etc., but appear they must if, through present acts, there is to be a reasonable expectation of securing future benefits.

Simply to avow blind faith in *planning* (the literature on planning tends to treat its value as self-evident) and to urge institutions to exert some managerial influence on their programs

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[2] James Doi, "Pressures to Increase Educational Productivity in Institutions," *Current Issues in Higher Education,* 1965, p. 114.

through an enlightened plan, borders on the pointless. Other aids are required to enable an institution to adapt itself to expected future demands on its resources while assuring, at the same time, that current programs are being operated in an acceptable manner. Significant changes in administrative procedures may sometimes be necessary in order to put useful information at the disposal of people who must develop plans and budgets. Such changes may be painful for an established institution. The procedures that give rise to useful data and their interpretation often cause greater overall economy of operation, but at the same time may be causes of organizational upheavals. Physical facilities assignment and planning are no exception.

In general, if the institution is to have the capacity to be self-regulatory and to generate guidelines useful in its own operation, it must study the collection and use of the information in which its plans are rooted.

Assume institutional management has developed criteria for good resource allocation patterns and wishes to detect flaws in them in time to take corrective action. (This is a hazardous assumption since few colleges or universities have been able to state such criteria.) In evaluating current performance, the institution must depend on information collected from and by its employees. Such collection demands a knowledge of what data are needed, and confidence in a system for collection, storing and reporting information. To understand information needs requires a deeper look into the nature of organizations themselves. This is initiated by taking a simplified look at the organization from the standpoint of basic information processing.

A model

It may be helpful to look at the organization's need for information as a problem in elementary system theory and regard the college or university as though it were an adaptive organism of a general type. The fact is that an institution is confronted by a bewildering array of things which it must sense and influence much as self-regulated organisms and machines are surrounded by inimical environments to which they must attempt to adapt.

The relationships connecting people and things in an organization are complex, but may be classified as functional groupings in the same way biological and mechanical functions can be assigned to the different structural parts of an organism. Thus, we may talk about the productive function, the motor function, the defensive function and even the sensing function.

The notion of adaptation to a changeable environment implies objectives or *states* toward which the system moves.[3] Physical movement on the part of the organism requires action which uses up some of the resources it has at its disposal. A drain of resources in turn causes further effort to be spent on storing up replacements for expected future uses. Each link in this chain of events depends on at least one

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[3]See A. D. Hall and R. E. Fagen, "Definition of System," *General Systems, I* (Bedford Mass.: Society for General Systems Research, 1956), p. 114.

part of the system knowing what is happening in the other parts. Before adaptation to a new situation can be undertaken the organism has to be made aware that some adaptive action is necessary. A particular action must be selected from among those actions which are feasible, and the organism must be directed to take the action chosen. The institution may be viewed as an organism that depends for its survival upon the flow within it of information about

- Resources available for use by the system
- Options for action open to it in carrying out its aims
- Rules for use in deciding what actions to take and when.

The requirements of an adaptive system seeking some definable ends are, in general

- That data on the rate of flow of resources and product be read by reasonably accurate sensors
- That the system be able to reference some set of prescriptive rules governing resource use
- That the system contain effective means of altering resource flows when adaptation to a changing environment makes it necessary.

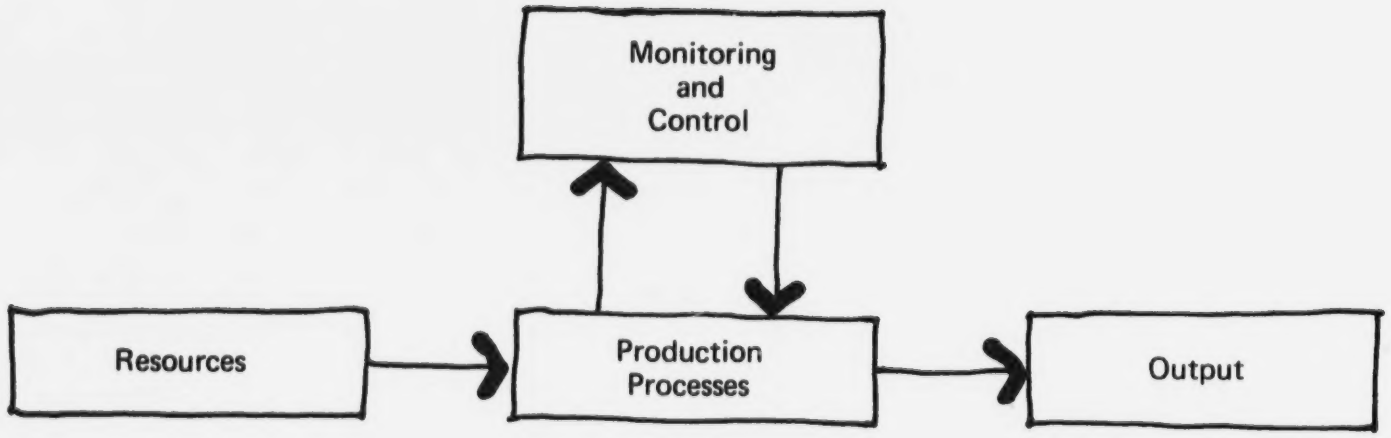

Figure 1.1: *Operation of a Goal-oriented Adaptive Organism*

Figure 1.1 is a variation of a common diagram showing the functions involved in the operation of a goal-oriented adaptive organism.[4]

The arrows connecting the blocks marked Resources, Production Processes, and Output represent the flow of physical objects and services. The arrows connecting Monitoring and Control to Production Processes, however, represent flows of information only.

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[4] See for example Miller, George A., I. Galanter and K. H. Pribram, *Plans and the Structure of Behavior,* (N.Y.: Holt, Rinehard, and Winston, 1960) Chapter 2.

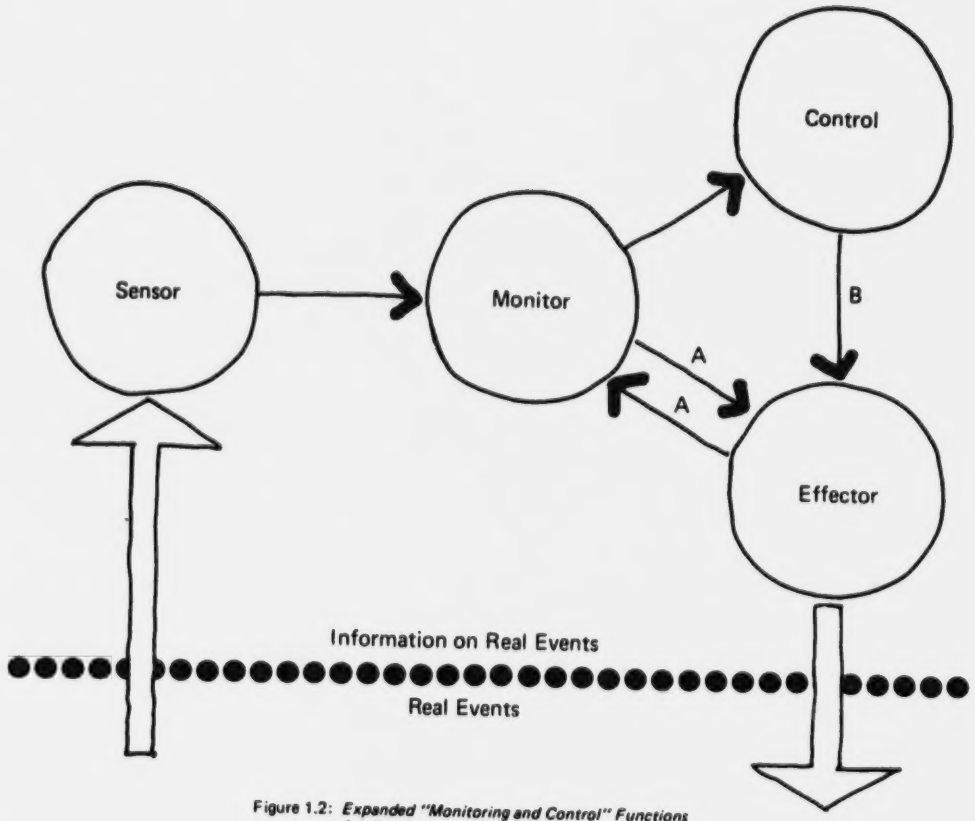

Figure 1.2: *Expanded "Monitoring and Control" Functions*
A = Deviations from Effector (plan)
B = Corrective Actions

It is useful to expand the Monitoring and Control block of this diagram into the functional components shown in Figure 1.2.[5]

This general diagram can be used to describe the need for various functions in living organisms, many machines and, for our purposes, human organizations. Sensors measure the quantity, type and rate of resource use in a series of productive procedures. Data gathered by the sensors are then compared in the monitor with prescribed or *planned* levels and patterns. If the operating rules set up in the *effector* are producing the expected results, the plan remains in force, unchanged. But consistent deviations of current sensor readings from planned or expected levels are reported to a control function. The latter directs corrective changes (line B) in resource flows designed to eliminate the deviations from plan detected by the monitor (lines A). These *management* changes are in the form of alterations to the guidelines,

[5]Adapted from L. Bertalanffy, "General System Theory – A Critical Review," *General Systems, VII* (Bedford, Mass.: Society for General Systems Research, 1962), Figure 1.

policies and procedures contained in the plan itself.

Assuming colleges and universities wish to adapt to their changing environment and be goal-directed and well-managed, this simplified model of organizational information requirements provides a crude picture with which to begin analysis.

It is fairly easily demonstrated that lack of essential flows of information in most organisms will seriously impair their ability to survive. Human organizations can be shown to perform each of the functions shown in Figure 1.2 in more or less effective ways. Serious inhibition of the information flow between functions must reduce the efficiency of resource use and reduce the likelihood of the organization's meeting its goals. How effectively and efficiently these functions are performed may be highly variable. Both operational effectiveness and efficiency vary with such things as organizational structure, information media and formats, and the set of procedures or rules by which the conduct of each function is governed. Given two organisms with like organizational and physical features and similar environments, the one better served by its information system will be in much better condition to compete for and economically to use scarce resources. Next consider the way a particular type of organization, for instance an educational institution, might perform its adaptive or management functions.

Resource allocation

The mechanism through which allocation of available resources is accomplished at a college we shall simply call its *resource management system.* This mechanism is made up of the people, equipment, facilities and information that are usually grouped under the heading, *the administration.* For the purposes of discussion we shall pay particular attention to the information itself, rather than to the people and machines that move it around and act on it.

What do we mean by *information?* It is *symbols that are intended to describe things or people.*[6] When we wish to know something about employees, students or physical facilities, we don't need to see or physically count them each time in order to know their properties. Rather we refer to files describing them in numbers, alphabetic characters or some other symbols. Data contained in these files originate when meaningful transactions involving system inputs and outputs are recorded. They are then stored for later reference. Examples of inputs are hours of human effort, services of equipment and room space, and units of supplies and materials. Outputs might be quantified as credit hours completed and dollars worth of research performed. The number of records to which we need refer varies with the number of entities (people and things) considered to be of consequence and the size of each record with the number of attributes or characteristics of each entity we wish to track (hours worked this week, age at last birthday, cost per hour of equipment use).

Simply counting different types of records can often generate meaningful statistics. The

[6] For a more thorough discussion of information and its various forms and meanings, see Colin Cherry, *On Human Communication* (Cambridge, Mass.: The MIT Press, 1966).

information compressed in these statistics is useful in projecting future resource requirements and in developing rules for governing the flow of the resources or outputs they describe. By planning future transactions, we avoid the need to interrupt the system's production processes while ad hoc decisions are made.

What is meant by a *transaction?* A transaction is *an act which either effects an increase or decrease in the number of units of an entity*[7] *under the control of the organization, or causes a change in the attributes of certain entities.* An example of transactions of the first type is provided when a University sells a piece of land, signs a contract with a new professor or receives money for a nuclear accelerator. When a currently employed faculty member is authorized a salary increase or an enrolled student completes another credit hour or semester of acceptable work, examples of transactions of the second type are demonstrated.

Carrying out a transaction requires a decision on the part of management. These decisions cannot be made explicitly each time we wish to perform a transaction, for they are numerous, and such a procedure is not necessary. After careful study of the institution's aims and recent operating history certain policies, guidelines or rules governing all transactions of a particular type can be drawn up. Together these guidelines and policies constitute a plan for the operation of the organization. *It is by the study of the information in the institution's files that the bases for decision-making are developed.* The desired transaction patterns by which resource allocation is to be accomplished is embodied in a plan. These patterns continue until policies and rules themselves are changed, added, or deleted.

In recent years demand for timeliness of decisions has increased. Acting as both a cause and an effect of this demand has been the increased availability of computers for use in making policy studies. It should be made clear that an information system generally cannot consist wholly of computer-legible files (people still must get into the act at some point) and that conventional accounting machines and manual files still represent the most economical ways of handling many kinds of information. Conventional methods promise to remain quite important for the foreseeable future. As progress is evident in the architecture of computing machinery and the arts of system analysis and design, however, the relative economy of using Electronic Data Processing (EDP) instead of manual substitutes will dictate increasing dependence on them.

Whatever information is collected and regardless of how it is organized into files or how it is used, there must exist a group of people, files and perhaps machines devoted to creating, maintaining and reporting from it. This specialized part of an organization has come to be called its *information system.*

It is important to recognize that an information system used to manage resource allocation is made up of distinct components or subsystems that are interdependent. Many decisions require a

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[7] Resources, or any asset, though they can assume both positive and negative dollar values in financial accounting, are for our purposes more appropriately viewed as physical units except where money itself is the asset accounted for. (See Ijiri, Y. *The Foundations of Accounting Measurement.* [Englewood Cliffs, N.J.: Prentice Hall, Inc., 1967] Chapter 5.

variety of information developed from different files. All files must be responsive to each potential user in order to meet the objectives of the information system itself.[8] This fact in turn dictates that each potential user must express his needs clearly at the time files are designed.

Information theory makes a fundamental point with regard to the symbols we use to record data on our files: that these symbols should not be confused in our minds for the actual things and relationships they claim to describe.[9] Short of duplicating the object itself, a completely accurate description of it is impossible. Therefore, we must deal with symbolic representations of it. Limitations in the usefulness of statistics developed from transaction-level data derive from this fact. We ignore it only to our pain.

Even small institutions operate resource management information systems that are complex in terms of a single person's ability to understand and control any one of them. In fact, such systems tend to be so complex that useful discussions of information system design and development often must be limited to a *subsystem,* devoted to describing only particular types or related groups of transactions. Nonetheless, one should not ignore the fact that no subsystem operates alone, but rather must function as a part of a whole. We shall discuss herein only those parts of a resource management system which are intended to serve physical facilities planning. It should be remembered throughout, however, that careful integration with the rest of the organization's information system is frequently critical to the effectiveness of its parts.

Room space as a resource

In the language used above, a unit of the entity *physical facility* can be described as a room or, at a different level, as a building. To build a file describing rooms, properties any unit can have that will be of importance must be known. In turn, how the room as well as its building function as resources of the institution must also be shown.

There is a tendency to look upon rooms and buildings simply as passive shelters of men and equipment bustling about in pursuit of goals that have little or no relationship to the room itself. The rooms, indeed buildings once they are built, are sometimes considered *free goods,* of little concern to a program manager in the planning and execution of his work. A room's shape, size and other attributes are of little concern to people bent on the performance of current tasks except when their program is being initiated and the question, "Where will we locate?", must be answered. When the petty but expensive irritation of painting or renovation occurs, a room's characteristics again tend to become important to its users. Even so, occupants are seldom conscious of a room as an entity, much less as a part of a productive process.

Nevertheless, rooms do contribute significantly to project results by accommodating or inhibiting

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[8] Generally an information system's objective can be stated, "to assist management in making more timely and valid decisions."

[9] See Ijiri, *op cit.,* pp. 6-13.

activities of different kinds.[10] Walls provide doors, windows, connections for power and other utility lines, and privacy. In rooms where water or other fluids are piped in, disposal tubes must also be provided. Ceilings contain threaded holes for the insertion of lightbulbs. Room shape and ceiling height vary radically if the activity housed is food refrigeration or the staging of plays.

In spite of the importance of a room in program operation, the tendency to assume the passivity of room space is very strong. Institutional accounting systems sometimes provide the means for ascertaining the operating or capital costs of a room.[11] But, such costs have seldom been associated with, much less charged to, specific user programs. It appears to be a prime job of institutional management to compensate for this denial of economic incentive. If programs are not obliged to meet all their real costs including the cost of using space, some other method of controlling and limiting space use must be found. A central agency for the allocation of space to users is the usual answer.

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[10] C. R. Carpenter and others. *A Faculty Office Study: Design and Evaluation.* New York, N. Y.: Educational Facilities Laboratories, Inc., Report, Dec. 1961, p. 18.

Lawrence R. Good, Saul M. Siegel and Alfred Paul Bay. *Therapy by Design: Implications of Architecture for Human Behavior.* Springfield, Ill. Charles Thomas, Pub., 1965, p. 193.

Hugh L. Hemingway. "Creativity and the Physical Environment", *Research/Development,* v. 15, Mar. 1964: pp. 49-52.

Stuart Stoke and others. *Student Reactions to Study Facilities.* Amherst, Mass., 1960, p. 60.

[11] Francis E. Rourke and Glenn E. Brooks, *The Management Revolution in Higher Education,* (Baltimore, Md.: The John Hopkins Press, 1966) Table 4-3, p. 90.

PLANNING

Architects and other environmental planners generally recognize as their main concern the value of buildings as instruments of institutional policy as well as works of art. They are directly concerned with the activities to be housed and the characteristics each room should exhibit. In planning a building, architects are frequently obliged to plan with inadequate information on the projected uses of a new building and on the relationships it is to have with existing buildings, exterior spaces and other activities. They are thrust into a position which requires them to operate under many assumptions about user programs on which they have limited information.

There seem to be at least three basic reasons this situation exists:

- There seldom exists a store of information concerning current room types and uses which is adequate for projection of facility needs
- Traditional methods of room assignment, and resource allocation in general, at institutions of higher learning is inimical to a *space management* function and tends to reject it
- Instructional and research program directors are not confronted with the costs of poor planning in an explicit manner, nor are they or their projects rewarded with the benefits of improved planning.

Building (room) space is not given the prominent or explicit place among valuable resources in the allocation process that it should have. For instance, if the budget of a research project were charged regularly with a *rental* for the space it occupies, there would be an incentive for the project director to keep space use to a minimum regardless of the importance of floor space to the work being carried out. His accounting statements depicting his position with regard to cummulative expenses and unexpended budget would serve as a constant, obvious reminder of the part space plays in the costs incurred by his project. Just what basis an institution might use for setting *rentals* will be discussed in more detail elsewhere.[12] Suffice to say that any reporting method which serves to convert room space from an apparently costless, passive *assumption* under which programs operate, into current services for which users are charged would encourage its more economical use.

A note on budgeting

Space management is more nearly akin to budgeting than any other function in the institution, though they seldom come under the same office for administration.[13] The reasons may be that there has been no convenient way to depreciate buildings in an educational institution nor any other handy way to express in dollars the value being received by the program from room space, or that the budget proposal derives power as a management tool from the fact that all resources comprehended by it can be quantified in dollar terms. (This means dollars can be diverted by management from one type of resource or program to another in search of greater economy or effectiveness.) The space plan deals in square feet, rooms and student stations. In determining non-space resources both acts of allocation are done in an analogous manner however. Budgeting and space planning are

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[12] See Appendix of this volume.

[13] Rourke and Brooks, p. 98.

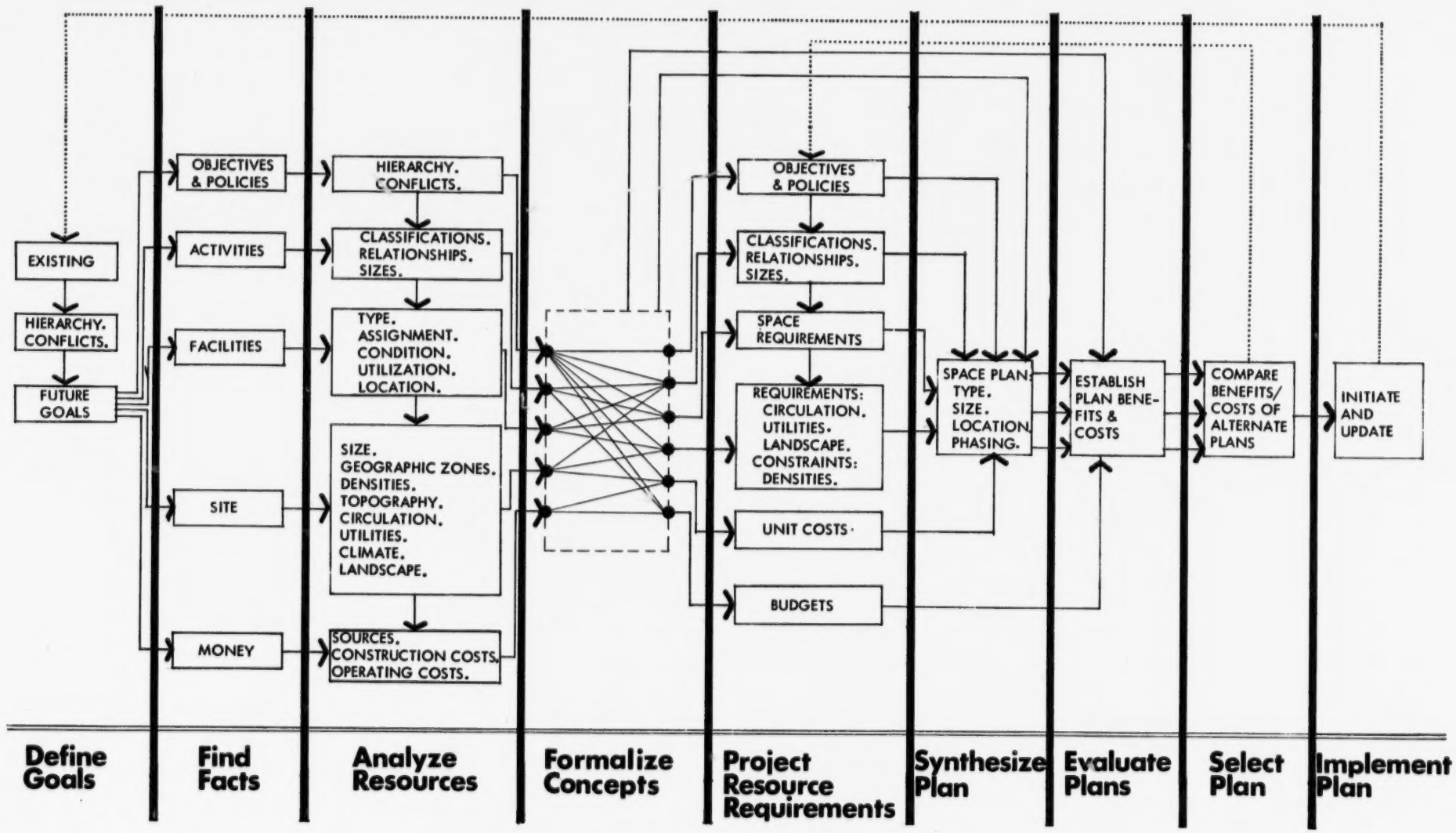

Figure 1.3: *Campus Planning Process*

essentially part of the same function: resource allocation. The budget and perhaps the space plan are ultimate vehicles of administrative decision. All other studies, edicts, manifestos, and records are merely inputs to the procedures which commit the resources of the institution to a definite course of action in the budget. *Only when funds are committed can a decision be considered finalized.* Space assignment should involve the same degree of official commitment as the budgetary distribution of approved funding.

Two routes to this end are possible. Fiscal accounting might reduce services received from space to dollar figures and institute official records for the control of space assignment and use (i.e., budget and expenditure); or a completely separate *space management* and accounting function can be set up to administer a space plan. The latter course has been taken most frequently.

Regardless of which alternative is chosen, information of a standard nature is needed on each unit of space available for assignment. Only by assuring that such information is available can reporting for control purposes be possible.

In order to enable such a method of reporting it would be necessary to classify rooms into categories or types that would be sufficiently homogeneous, and few in number, to allow for the development of a practical scheme for costing and budgeting room use. At the same time the

bases for classification should be descriptive enough of specific room attributes to allow for the assignment of specific activities to a type of space which can accommodate them.

Space plan administration

Space administration and planning is plagued by a dual weakness: centralized authority usually dispenses permission to use space while program planning is conducted by specialists in particular disciplines as though in isolation from institutional management. The nub of the problem: different people with different aims perform these functions. On the one hand, a space administrator who is likely to be very sensitive to what building space is costing the institution, perhaps after hearing the justification put forth by the potential user, commits space at no apparent cost to the user. On the other side of the transaction, people highly trained in research and instruction at the program management level take space into their plans in the form of absolute *needs* with little regard for its cost relative to the other resources required to operate the program. It is here that management does not operate as it should.

Two conditions become apparent: The centralized space allocation authority, even if it had sufficient time and people, cannot predict the effects of increasing or decreasing the amount of room space used in a particular program, since it knows very little about the way in which space is used in the program. The program manager is in an excellent position to project requirements, but he cannot, at his own discretion, decide how much space he should have for his own program; nor should he. There being no simple way to decide with whom the final responsibility should rest for rationing total available space among competing programs, the opinions of the individual or group given bureaucratic control over room assignment frequently hold sway. *Homestead rights* are generally the most important determinants of space assignment. Time honored assignment patterns become permanent and seldom subject to review. In any case, the best interests of the program are likely to be poorly served. The problem urges us to look at the procedures used to ration space.

There seems to be three methods that might be used to ration space to competing programs:

- The centralized space *czar.* Individual space requests are considered by one person (or a small group of people) and allocation made on the basis of what is considered by him to be the best pattern.
- Space *wholesaling/retailing.* In this system a block of space is made available to a group of related programs for parceling out among its constituent parts
- *Pricing or costing.* Basically this method would call for the completion of two tasks: the setting of prices or costs on types of space at the beginning of each budget cycle, and charging user programs for space actually used.

Granted that some method of space allocation is in use, how is management to be sure sufficient new space of the right kind will be made available to expanding programs? Facilities planners are obliged to wrestle with the uncertainties raised by this question.

Planning physical facilities involves people and information from all areas of the institution.

14 Figure 1.3 displays the prime blocks of information used in planning. What is commonly accepted as facilities planning (architectural design and construction) only starts at the right hand end of this series. Management concern with planning should begin at the left hand end of this process with the statement of institutional goals and collection of data. Projection of resource requirements and supply constitutes the institution's plan of operations and represents an information gathering task of considerable proportions. Physical facilities form a part of this projection.

It is helpful to relate the people involved in planning in a standard organization chart to the part they should play in generating these blocks of information. Figure 1.4 illustrates that a number of types and levels of people are involved in the process and that their tasks are quite different. It would be inadvisable, perhaps impossible, for one man or office to undertake all the required activities. Facilities planning requires a commitment of time and effort from all involved.

ADMINISTRATIVE PERSONNEL (type)	Program Management (line) Clerks and Inspectors (Staff and line)	Institutional Planner (staff)	Top Management	Program Management (line)
FUNCTIONS Performed	Find facts (Collect and Store)	Analyze, Project, Synthesize, Evaluate	Evaluate, Select	Implement and control
INFORMATION generated or used	Raw Data: Activities, facilities inventory, financial accounts, policy statements, program, institutional goals	Plan Alternatives: Costs, space allocation, objectives	Space plan and capital budget	Current exception reports

Figure 1.4: *People, Functions and Information Involved in Facilities Planning*

Two things must be done to make the current version of a plan serve its purpose as a management tool: People who must observe its provisions must be made fully aware of the plan and its implications, and all segments of the plan must be compared to expose conflicts and inconsistencies. Simple failure to communicate and coordinate estimates of future needs probably generates much of the imbalance that appears in the stock of space at the disposal of many institutions. (Considering the dominant concerns of most institutional planning officers, it is logical that they assume this coordinative/communicative function.) All the linkages essential to the planning process between the individual program planner, the president, and the current version of the institution's building program must be established and appropriate guidelines formulated. Faced with this sort of responsibility, the planner also requires a familiarity with all the major problems and goals of the institution, significant authority or access to it, and a fund of experience gained in administration.

Information for facilities planning proves elusive in an institution not organized to provide it. Two groups are rising to meet the need for generating this data. One group provides a space management function and the other, institutional planning or research. The latter group often acts as coordinator of information about the academic plans of various programs. In this way, at least, common units of measure and internally consistent projection rules tend to be provided for. Space management, however, generates the major portion of the raw data of direct use in facilities planning.

SPACE MANAGEMENT

17/18

Space management consists of the assignment of building space (both existing and future) to activities (current and planned) in a manner that will result in efficient and effective use of the physical facilities under the control of the institution. *Activities*, as used herein, are assumed to be space-using and are generated by people[14] employed under programs designed to carry out the aims of the institution.

Figure 1.5 shows the principle groups of information used and basic actions performed in the two functional areas involved in the assignment of room space. This chart has an analogy in each resource management area, eg, personnel, equipment, and material. The rationing problem is not so acute for other resources incurring current expenditures each budget cycle as for facilities, since current budgets can be altered and corrected on relatively short notice. Figure 1.5 points to the end result or purpose of these actions: *Produce Outputs,* or *Program Performance,* in the more accepted phrase. Acceptable performance depends in part upon how well space demands have been anticipated.

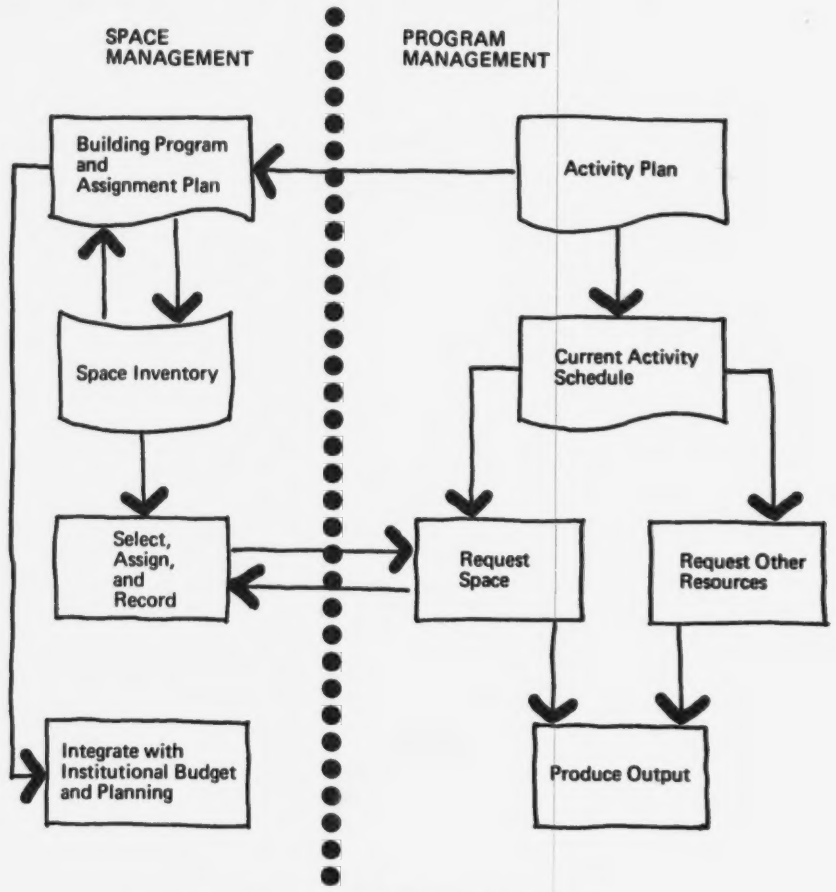

Figure 1.5: *Information and Actions Relating Space to Program Planning*

Building construction and renovation requires extended lead time. The useful life of a building is long when compared to other kinds of resource. Because of the long time period which usually must pass before a building is *used up*, decisions affecting its design and location must remain valid for the life of the building or give way to costly (and almost as longlasting) renovations and alterations.

How is space management related to program planning? Figure 1.5 shows that both user program manager and administrator are directly involved. In the process of planning for space assignment, expected output loads (credit hours, man-years of research or some other measures) are translated into space requirements.

This conversion of projected activities into space needs may not have been done consciously; but, if programs are to be properly served with sufficient space of the right kind, the space plan must include it. In the case of a space plan calling for new buildings, this conversion should be completed long before a specific quantity of room space is cast in bricks and mortar. *The basis for smooth selection and assignment in the development of a building program lies not in a*

[14] These people are conceived of as using up materials, occupying space, and wielding equipment. Housing of largely self-sustaining equipment (eg, boilers, elevators, hoists, etc.) or storage of materials can constitute space-using activities as well.

set of diplomatic administrative procedures so much as in the degree to which activities have been successfully anticipated. These estimates, in turn, depend heavily upon the amount of planning done by the management of each program.

In order to provide for the assignment and use of space, certain standard data must be captured, recorded, and processed into reports from time to time. Without these data the space office manager cannot operate effectively and the space plan has little meaning.

To help determine what data are needed, suppose a potential user submits a request for a room. Request in hand, the space office manager must search the organization's inventory of assignable rooms, select the appropriate one, assign it to the requestor and record the assignment. These procedures appear in simplified form in Figure 1.6.

How does the monitor know which room to assign? He refers to a current space assignment plan which portrays a matching of expected

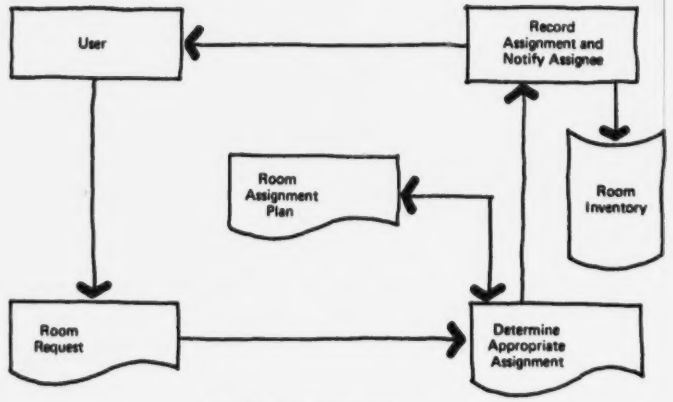

Figure 1.6 *Room Assignment Procedure*

activities with compatible room spaces. Information for use in the plan is drawn from a file of room records kept current with additions and deletions of space as it changes quantity and form. The plan uses a variety of information about the room. It serves as a source of information about past and planned assignments. The plan puts into effect space assignment policies developed by the institution's management at some prior time and is reviewed periodically to insure its continued validity. The data used or generated in this process are the identity and description of the room and the identity and activity of the user.

Basic data generated by at least four administrative areas are required to provide the information outlined above: top management, line or program management, space management, and accounting. Of all the files of interest in planning to which these areas contribute, however, the space inventory provides the data most directly useful in facilities planning. For this reason, we will examine next some of the characteristics of a suggested space inventory file.

Room inventory data requirements

In keeping records for use in room assignment and planning it is necessary to perform at least the following actions:

- Generate a record for each room (to note that the room exists)
- Identify the room (to make it possible to reference it uniquely)

- Provide for the assignment of rooms to users (to find the name of the assignee and the use to which the room is to be put).

If all rooms matched alike the requesting programs, these three information groupings would be sufficient. But in what way is the fact provided for that different activities require different types of rooms? A class cannot be conducted in the room built to house a central heating furnace. Laboratory research in chemistry generally requires an inlet for water and a drain. A standard room that would make an adequate office would not suffice for the chemist without major alteration. To provide for such requirements, the room record also must mention

- Type of room, based on physical characteristics.

All the data needed to assign a room to a user for one point in time is now available. But what about the period of time over which the user expects to exercise his assignment? A room will probably be valuable to a user over a length of time, say the period for which his program is funded. Because assignment must have some time dimension,

- Assignment term is added as the final item of information needed by the monitor to record an assignment.

A procedure for room assignment can be established best by designing the output reports so that they are consistent with data in existing files.

As a practical matter, the items of information mentioned in the above paragraphs must be arranged in a set of files offering quick and easy access. Record formats may vary with local preferences, but the essential data to be contained in the files tend to be the same from one institution to another. The first action, establishing the existence of the room, can be handled simply by creating a record for it. At that time the room should be assigned a unique identifying name or number such as building and room number, thus satisfying the second requirement above. For assignment we shall enter the program code identifying the line organization or budgeting department to which the room is assigned, the name or codes identifying users (eg, social security number for individuals and budget codes for programs or departments), and the particular use to which the room is to be put. The term of occupancy may be carried in this segment of the record as well.[15]

Room types

In Figure 1.5, space/program planning, specific activities are matched with particular room types. Room type should describe the physical character of the units of space resource supplied in response to the space-demanding activity. There exists a scheme for typing rooms developed in 1967 by the United States Office of Education (USOE) in consultation with a panel of planning specialists

[15] Intended changes in assignment — indeed the space plan itself — should probably be recorded in a separate file or document for reasons of processing efficiency But making these data also part of the same logical computer record is feasible and, as the costs of storage media and accessing fall, it would be economical as well.

from a number of schools. It has been published in manual form[16] and is being used widely by many institutions of higher education.

The USOE scheme makes an attempt to avoid the use of "terms associated with function or subject matter areas" to the extent possible within the limitations of the data they suggest collecting.[17] Employment of function-related terms presumably would have resulted in a typology reflecting unique room uses. A true room type might be able to accommodate one or more uses. The room should be unable to change type without physical alteration.

It seems that USOE did not go far enough, however. If the aim is to obtain a method of typing a room which will allow any user, architect, construction engineer or budget analyst to use a single term which refers to the same or similar rooms, reference must be made exclusively to the physical characteristics which the room exhibits, characteristics which can be observed objectively and intentionally designed into the room. During this project, Duke University built a room inventory containing among other things

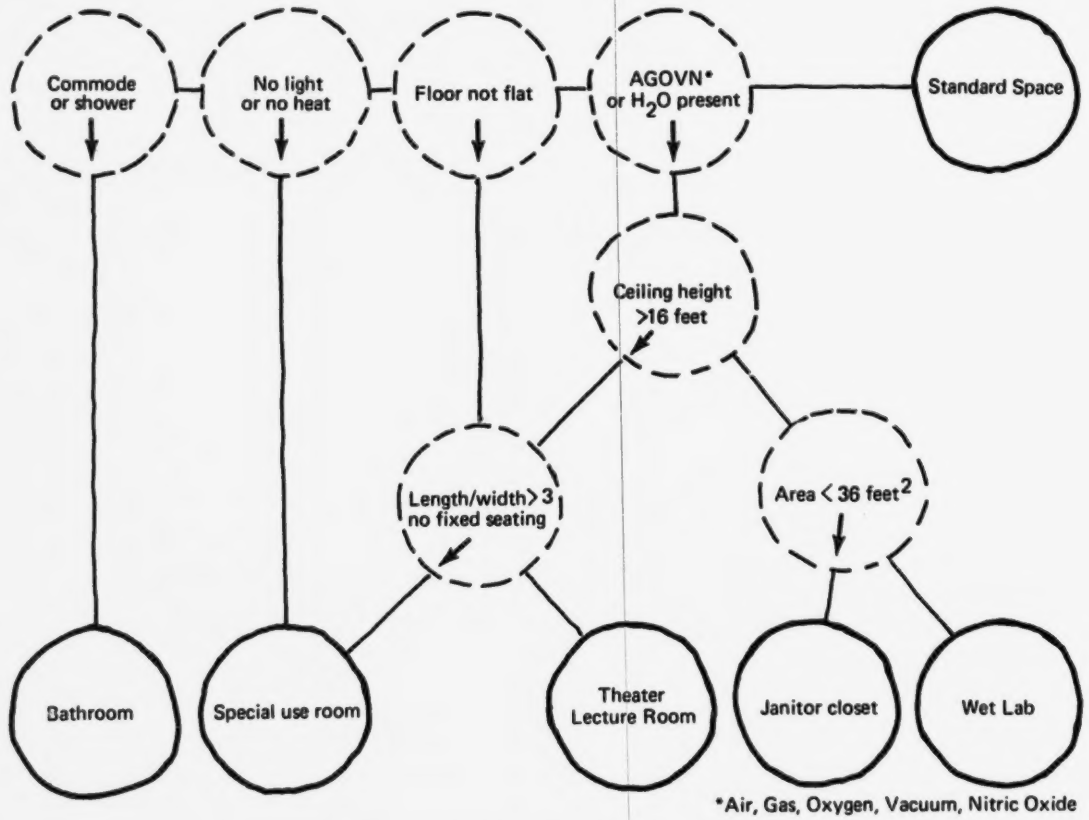

Figure 1.7: *Room Type Classification Scheme*

data describing each room's physical features. From these codes and quantitative statements a computer-driven procedure was developed to assign a type to each room.[18] The number of types was kept to a minimum. They are shown in Figure 1.7 along with the physical characteristics that were used to define them.

It will be noticed that area in square feet is not a criterion (except in the case of janitor's closet), though it is quite an important physical characteristic of rooms. The square foot measure is reserved to be used primarily in the assignment process as the standard unit of space quantity, not a definer of type.

The physical characteristics of rooms which were chosen to be recorded are of a built-in nature, and include only those likely to be costly to change. In other words, ignored were movable equipment, immovable fixtures which are relatively inexpensive to add or remove, and features with little relevance to potential users. An exception to

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[16] *Higher Education Facilities Classification and Inventory Procedures Manual.* (Washington D. C.: National Center for Educational Statistics, USOE, 1968).

[17] *Ibid.*, p. 49.

[18] Program listing and data on Duke's inventory of rooms may be obtained from EFL.

this rule was the inclusion of number of stations (fixed or movable) in order to satisfy the requirements of room utilization studies.[19]

In costing rooms, it is necessary to take into account their physical feature. In addition, costs that fluctuate with the type of building structure and utilities have an effect on individual room costs. Therefore, the room type is not meant to be the sole determinant of room costs, but rather an indicator of inflexibility in room use — an inflexibility born of the relatively high costs of conversion of one type of room to another type.

It is suggested that this typology, or a one which is dependent upon objective criteria, better serves some of the purposes of a space inventory expressed in the USOE Manual than the scheme proposed therein. The purposes in point are:

- Assignment of space appropriate to organizational units (ie, activities seeking space of a definable type)
- Conversion of space from one use to another
- Projection of long range building needs
- Determination of operating and capital budget requests
- Determination of indirect cost rates for sponsored projects.[20]

Nevertheless, both USOE codes, and the types just described, were established for each room at Duke; one for designation of true room type and the other for room use.

Room use

A tabular distribution of rooms at Duke was prepared along two axes: the room types developed by this project in the columns, and room types established by USOE in the rows. On the premise that type should be dependent on the physical features of a room, and since the number of USOE types (rows) exceed the EFL types (columns), we should expect rooms to cluster vertically along the columns, not to spread out horizontally along the rows. Such was not the case. Very little clustering was noticeable. Rather it was as though the USOE type codes described activities or uses which could be extensively substituted among space types as defined by this project.

In view of the fact that the Duke room inventory scheme needed a room use code structure, the USOE codes were collected as *room uses*. As such they have proved valuable since they can be of assistance in describing the quantity of a given activity conducted in space assigned to different departments and programs. It is quite appropriate that many uses can be accommodated by unspecialized room types. The assignment patterns for unspecialized space should suggest more efficient alternative uses where the opportunity exists.

This points up an unfortunate behavioral tendency among users of space: a room typed by some term which describes its use may become relatively inflexible. In other words, a room typed as an office is unlikely to be considered readily for other uses. On the other hand, a room of

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[19] It is suggested that non-fixed station counts be dispensed within utilization studies as well. Square-feet per station should be the standard, since it does not change and produces a valid measure of *capacity*.

[20] *USOE Manual*, p. 1.

24 Type A or *standard space* (of sufficient size) can be used as a seminar room, an office, a conference room, storage, a dorm room, or a lounge simply by changing furniture. Substitution of space among uses should be encouraged if by doing so costly new building or alterations can be avoided, and if the costs of reassignment are not too large.

Room uses and room types, then, are complementary attributes of a room and both should be recorded in the course of data collection. A particular use is assigned to a room as a matter of institutional policy. Further, because it is not fixed for any room, it is more akin to assignment than to physical characteristics, and therefore should be collected as an item of assignment data.

The details of all five kinds of room inventory data outlined above are discussed in Volume 2, Room Inventory, generated as part of this report but printed separately.

ACTIVITIES DATA

The use of room space involves a process. A person, a piece of equipment, or a batch of materials, (or some combination of the three) is accommodated for some period of time in a room compatible with the activities which define the use. An institution promotes certain activities because they represent ways of accomplishing objectives it wishes to encourage, and without which its goals presumably would go unattained. In short, activities, as we will employ the term, are the means by which the institution achieves its aims.

Room space of the right type is generally a requirement for the effective conduct of an activity. Nearly all instructional, research, and administrative tasks demand appropriate room space. Of course, on a sunny day classes may be held on the lawn, and botanical samples may be collected in the field. As a rule, however, all programs being promoted demand that the institution supply enclosed space.

It has been the purpose of the foregoing sections to show how information with regard to room space itself should be handled. To talk about an inventory or supply of space is to discuss only half the process, however. In order to analyze and estimate future space requirements we need another measurement system, a process for gauging the level of space-demanding activities. Such a system should be compatible with that used for recording data on space. We wish to be able to infer from some statement of planned activity levels the amount and types of space we shall be seeking, i.e., the room space for which we must budget and plan.

Suppose that there exists an identifiable flow of services from each square foot of usable floor space, and that this flow is of a type determined by the physical characteristics of the room in which it is contained. Further, assume each such square foot is available for use 24 hours in every day. In order to be of value in making projections, measurements of *uses* must have a time dimension and be assigned some amount of physical space per unit. Twenty-four square-foot-hours flow each day from each square foot of space. This flow constitutes a supply of service available for *consumption* by an activity. By using a standard quantity of space (in square feet) per unit activity for each activity, we are able to obtain a measure of *consumption* of space in square-foot-hours. An office of 100 square feet generates 2400 square-foot-hours of office space in a day. A nine-to-five administrator who has been assigned exclusive use of these 100 square feet, and who has an hour off for lunch, consumes about 700 of these square-foot-hours with his work each day (7 hours x 100 ft. = 700 square-foot-hours). While it may not be possible to assign the remaining 1700 square-foot-hours to any other person, they can be said to be consumed in housing or storing the administrator's belongings and files. The 2400 square-feet/day of assignable space is being consumed by the use *office*. Likewise the services of a special-use space equipped with furnaces is being totally consumed with an activity called *central heating* which is subsumed under the use *equipment housing*.

These examples represent a way of looking at two common uses of space. There are countless others in process continually, most of them somewhat harder to classify. To match all activities and room uses with all rooms, the activities to be considered must be refined, as in the case of room types, by some scheme of classification sensitive to the kind of analyses to be performed. The

requirements of a useful activity classification procedure might be:

- To divide activities into groups that lend themselves most readily to projection
- To classify activities using impersonal data maintained by the institution (eg, students, faculty, support personnel), since people themselves are most commonly the main factors in space use
- To include all significant space-demanding activities
- To keep the number of activities small and manageable.

The significance of a single space-using activity in this context is not always easy to determine. Nevertheless, such a classification scheme would be helpful in relating each activity, regardless of its importance as a consumer of space, to the kinds of analyses we expect to be relevant. In the light of the above aims, the following qualities were used to categorize activities:

- The ability of the activity to be controlled
- The function of the activity with regard to university objectives
- The type of person conducting the activity.

Control

Allocation of a resource, such as building space, to a use and, therefore, to one or more activities implies the exercise of control over its disposition. Adoption of measures designed to improve facility utilization rates requires such control.[21] Consequently, it is sometimes necessary to control the points in time and space at which activities are conducted. Control of people-hours of activity is commonly exercised by scheduling to obtain the maximum benefit from limited resources (people and facilities).

For example, general classroom space may be scheduled because of the benefits to be derived from economizing on an instructor's time. That is, enabling a high student attendance rate for each hour of faculty-class contact. Specialized space is scheduled for analogous reasons. Physical examinations, sporting events, and movies are examples of activities which must be scheduled into compatible space rather than being left to individual discretion. Without resort to scheduling, many activities would not be practical.

What is *scheduling?* It is not easy to state a useful definition. For example, a class is scheduled to begin at a particular point in time, say 10:20 am on Mondays, Wednesdays and Fridays. *Sick call* at the student health clinic, however, is not a point but a span of time (say one hour.) Nonetheless, in the stricter sense, the clinic is still *scheduled.*

The difference between types of scheduling – call them *point* and *span* – lies in the fact that a point-scheduled facility is generally required for an event or sequence of events which will be performed but once, or in a prescribed sequence and by a unit of resource such as an instructor or a cast of players which cannot conveniently be divided into smaller pieces per unit time. On the other hand, the span-scheduled facility can accommodate a flow of clients seeking an event or a series of related events (eg, checking out a

[21] We are indebted to John Keller, University of California, for the admonition not to over emphasize utilization rates as measures of economy. As utilization rises so do total costs, generally. At some point costs rise at a more rapid rate than utilization. More intense use of the facility which is costing more to use than other available facilities, or even a new building, is not warranted.

book) which can begin at any point in the span of time allowed, and can perhaps be administered by more than one unit of resource (library circulation clerks). If arrivals of persons seeking service exceed the capacity of the facility to serve them, or, even if the total activity load can be handled, if the level of activity is not evenly distributed over time, queuing results; persons in the queue must be served in some order (perhaps by time of arrival).

As becomes quickly apparent, a wide and unmanageable range of activities could be classed as *scheduled* under the more inclusive definition. Here, however, scheduling will be defined as the *point* variety. Unscheduled activities are those made possible over a span of time of any length. The conditions *scheduled* and *unscheduled* shall be used as an indication of the degree of control the institution exercises over the placement of the activity in time and space.

Function

A functional breakdown of facility-using activities suggests these categories: *academic* and *non-academic*. The former, in turn, may be divided according to the two main areas into which university goals generally fall: *instruction* and *research*. Activities which are primarily non-academic fall into groups according to whether they are *residential/personal* (sleeping, eating, grooming), *recreational* (TV watching, informal discussions, sports), or *administrative/support* (office work, janitorial, plant maintenance). In order to accommodate uses of space which are not dependent upon people, we must add the functions *storage, equipment housing,* and *dead space* (space under repair, renovation or construction).

Many activities in which a significant portion of the university population is engaged from time to time may not fit with precision into any one of the five foregoing functional groups. A category labelled *other* should be reserved to receive such activity designations. Because of peculiar space requirements and the effects these requirements have on facility location, the activity *transportation* is given separate treatment.

Type of person

To facilitate analysis along the same lines as the institutional budget, types of actors should follow personnel classification. These categories can be reconciled with *students, faculty, staff, other* and, of course, *non-human* to accommodate equipment and storage-related activities.

If the above describes adequately the three dimensions of space-demanding activities of interest to university planners, Figure 1.8 may be of use in activity classification.

Activities of direct importance to prime university objectives tend to fall in the upper left-hand cells of this table, and those of less direct importance tend toward the right-hand corner. Such a structuring of activities may assist in ranking the facilities problems associated with accommodating them.

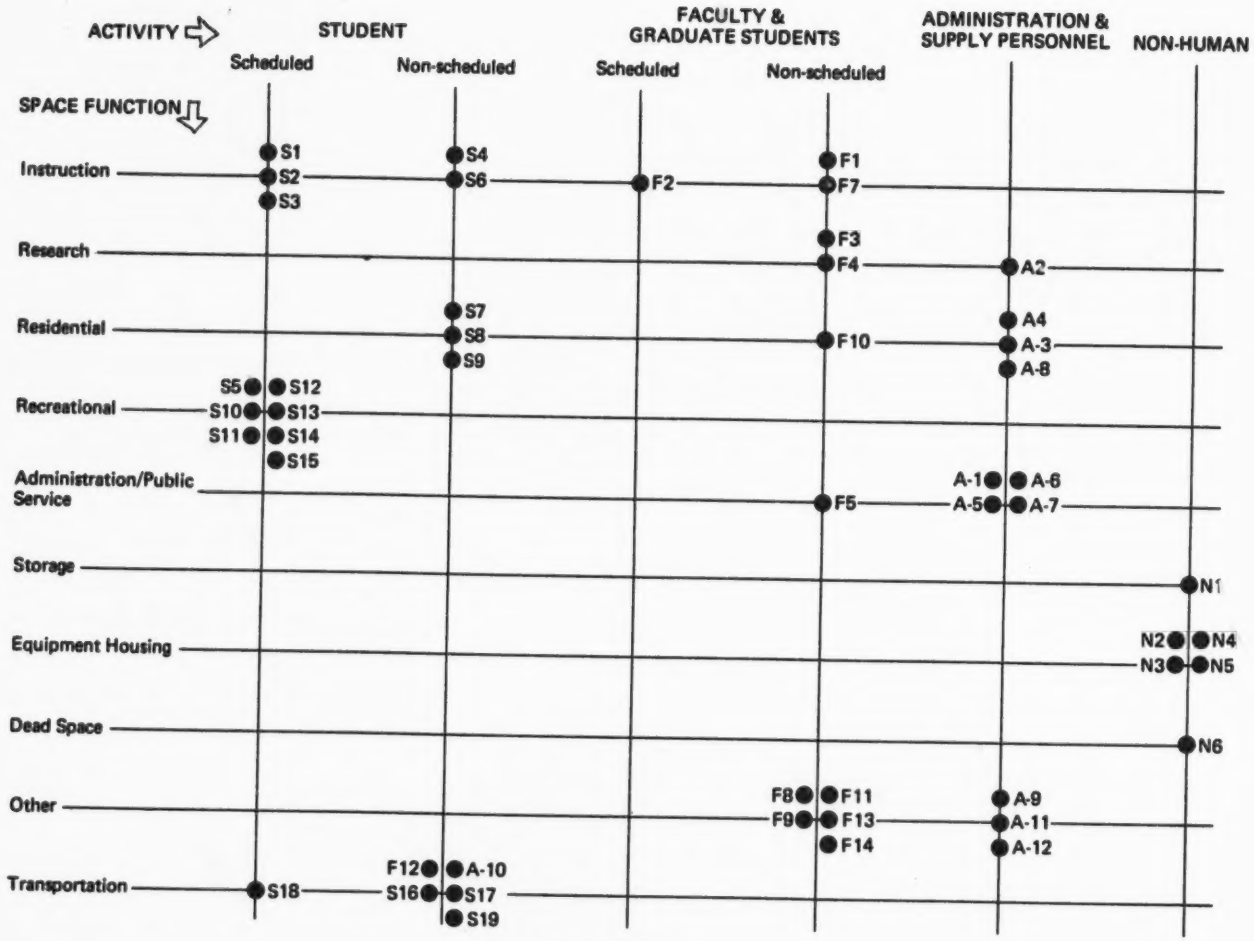

Figure 1.8: *Activity Classification*

An approach to non-scheduled activities

Scheduled activities such as attendance at classes and teaching labs have been placed under some degree of control perhaps, due to a simple need to ensure that students on one hand and professors, doctors and other professionals who serve them on the other know when and where they can find each other. The need to schedule has generated the data on which most classroom utilization studies are based. Other activities which consume large blocks of space, however, are ill understood and therefore frequently ignored. Because they are not scheduled, they are only observed infrequently and with difficulty. This project's aim has been to develop an instrument for collection of data on activities of an unscheduled nature.

Four kinds of data collection instruments were considered for use in this undertaking:

- Periodic traffic or occupant counts which rely on a collector who keeps watch at a building entrance or in a prescribed room, recording

people passing or occupants during or at the end of regular time intervals

- Unobtrusive mechanical counters accomplishing the same purpose (eg, a hidden photoelectric cell)
- Secondary indicators such as flow of dirty trays in the cafeteria, cigarette butts in the library lobby, or the volume of water used per unit time in the dorms[22]
- A diary or *time budget*[23] completed by a sample of individuals drawn from the university population itself.

The objective was to take a systematic approach to data on space-using activities. In view of this objective it quickly became apparent that a 24-hour diary represented the only instrument that would account for all the activities in which the respondents engage. In fact, only by using such an instrument could a simultaneous attempt be made to account for all human uses of all room space, to determine peak load levels of activity by type of space, and to relate activity data to the identifying attributes of the respondents. Opposing use of the diary were lack of experience and literature regarding diaries, the possibility that difficulty in filling out the instrument would damage the quality of response, and the possible high cost of collecting and processing the data. Nevertheless, in the interest of exploring the use of a new and promising instrument, the diary idea was developed and tested.

Following are some practical uses for the data collected by the diary:

- To provide an aid in scheduling. Information provided from diaries can provide a *feed-back loop* by which to measure the effects of schedule changes on non-scheduled activity levels and the use of non-class rooms.
- To provide a guide to building planners. Since the diary should increase the quality and coverage of figures on space uses, statements of space needs should attain greater precision. As new space is created (built), activity and space use patterns should alter. Did they according to expectations? What activities in which types of space diminished and which increased? Testing the validity of past decisions in this way can improve current ones.
- To test validity of capital budgeting formula standards of space quantity per unit of activity. For instance, student union, study carrels, bathrooms and library needs are affected by changing enrollments, but how much? If special-use space is not sufficient to accommodate the current level of an activity, to what type of space (and where) does the student's volition take him?

- To test the effects on activity patterns of changes in policy such as alteration of teaching methods, campus residence requirements, library or store hours.
- To measure the degree of dependence of the institution upon the surrounding community. Any time not spent on the campus is generally

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[22] For a discussion of methodology and examples see Eugene J. Webb, Donald T. Cambell, Richard D. Schwartz and Lee Sechrest. *Unobtrusive Measures: Nonreactive Research in the Social Sciences* (Chicago: Rand McNally and Company, 1966).

[23] The *Time Budget* concept was based on material found in P. A. Sorokin and Clarence Q. Burger, *Time Budgets of Human Behavior,* (Cambridge, Mass.: Harvard University Press, 1939). Our reasons for not going further with it are discussed in the manual on activities data collection also generated by this project.

spent in consuming the services of the community and privately-owned facilities.

To validate the data gathered with the diary, it is advisable to conduct parallel studies using traffic counts or other measures. (While planned, unfortunately, this validation was not done in support of this project's diary exercise.) The combined diaries yield magnitudes representing the aggregate hours occupants spent in a room during a period of time, the number of people in a room at a given time, or traffic past a point. To the extent these figures can be substantiated by spot-checks over time, confidence in the validity of these data is enhanced.

Activities analysis

A general analysis of the distribution of student time is shown in Figure1.9 general categories of *Academic, Residential, Recreational, Transportation,* and *Miscellaneous* are summarized, together with detailed activities within each category. The three major blocks of time occur in sleeping (31.4% of total time), study (16.8%) and lecture (6.8%). Figures 1.10

Figure 1.9: *Distribution of Student Time as Summarized from Diaries*

ACTIVITY	STUDENT HOURS	PERCENT OF TOTAL HOURS	STUDENT HOURS	PERCENT OF TOTAL HOURS
Academic			**12,441.00**	**26.00**
Lecture	3,270.00	6.82		
Laboratory	768.00	1.60		
ROTC Drill	37.00	0.07		
Art Work Rehearsal	171.00	0.35		
Study	8,043.00	16.78		
Counselled	152.00	0.31		
Residential			**20,028.00**	**41.80**
Sleeping	15,059.00	31.41		
Eating	2,773.00	5.78		
Per Hygiene	2,196.00	4.58		
Recreational			**7,993.00**	**16.60**
Read/Hobbies	2,754.00	5.74		
Bull Sessions	2,127.00	4.43		
Sports	790.00	1.64		
Movie/Game	692.00	1.44		
Work Student Organization	545.00	1.13		
Party	1,085.00	2.26		
Transportation			**3,498.00**	**7.30**
Walk	1,854.00	3.86		
Bicycle	14.00	0.02		
Bus	515.00	1.05		
Car	1,125.00	2.34		
Miscellaneous			**3,972.00**	**8.30**
Wait	517.00	1.07		
Errand	874.00	1.82		
Part Time Job	463.00	0.96		
Other	1,604.00	3.34		
Other Unspecified	514.00	1.07		
Total	**47,932.00**	**100.00**	**47,932.00**	**100.00**

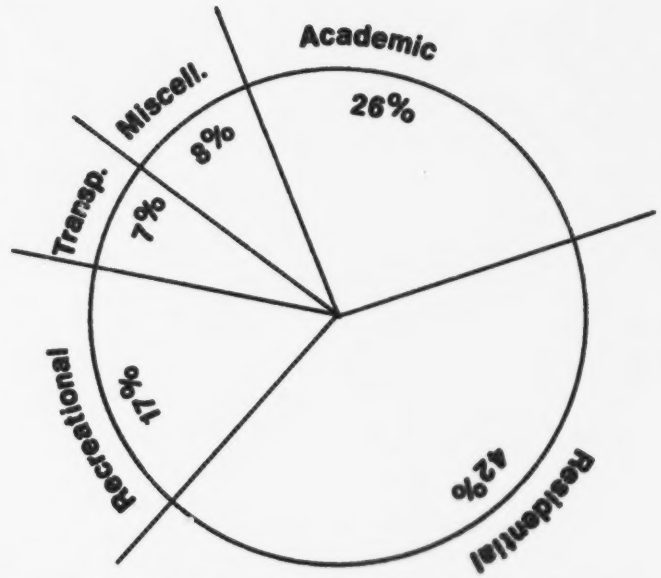


Figure 1.10: *Distribution of Total Student Time during One Week*

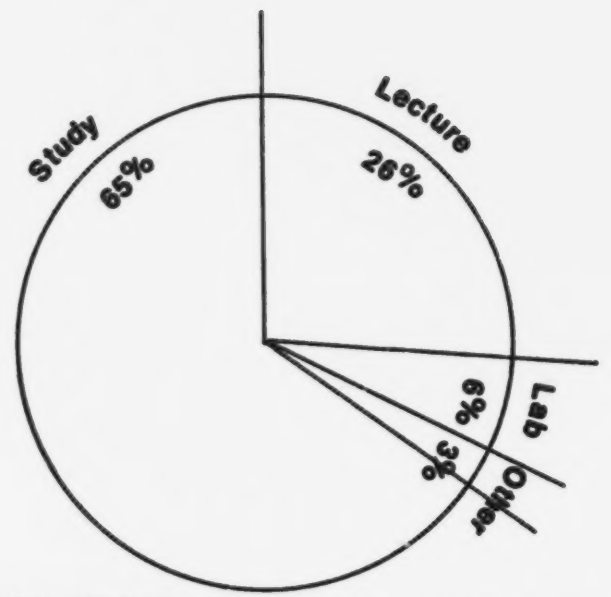
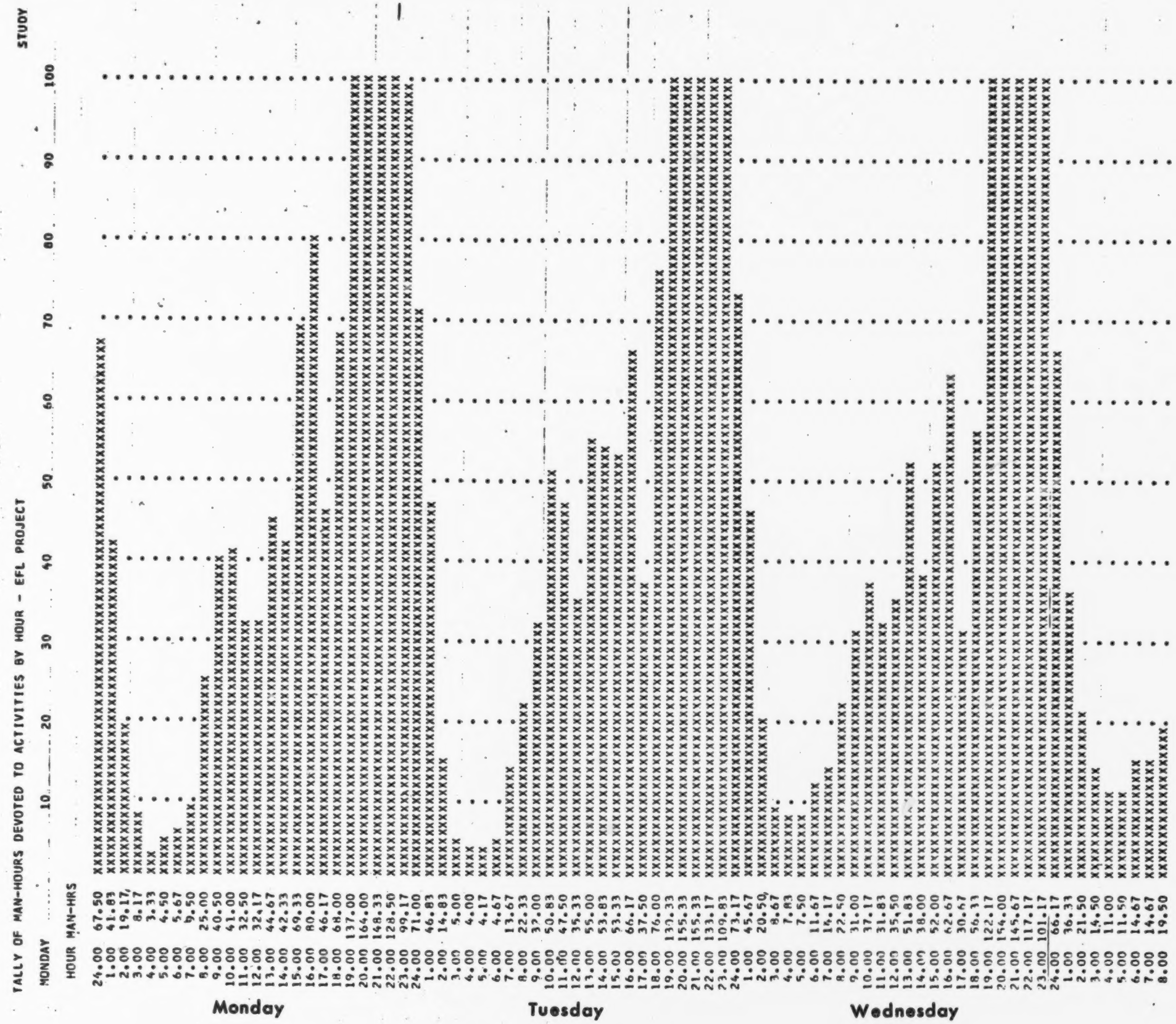


Figure 1.11: *Distribution of Student Time Spent in Academic Activities*

and 1.11 show the distribution graphically of total student time and of Academic time respectively.

Also of interest is the pattern over time in which these activities are generated. Figure 1.12 shows a histogram of the numbers of student hours generated in study. The first column of figures shows the hour of the day (24-hour clock); the second shows the number of student hours recorded in study during that time period. Each "x" denotes 60 minutes of study during that time period. This graph is a composite of several sheets of computer printout. The graphs which follow it show the printout as it is generated by the computer and are for the activity of *lecture.*

Figure 1.12: *Tally of Man-hours Devoted to Activities by Hour*



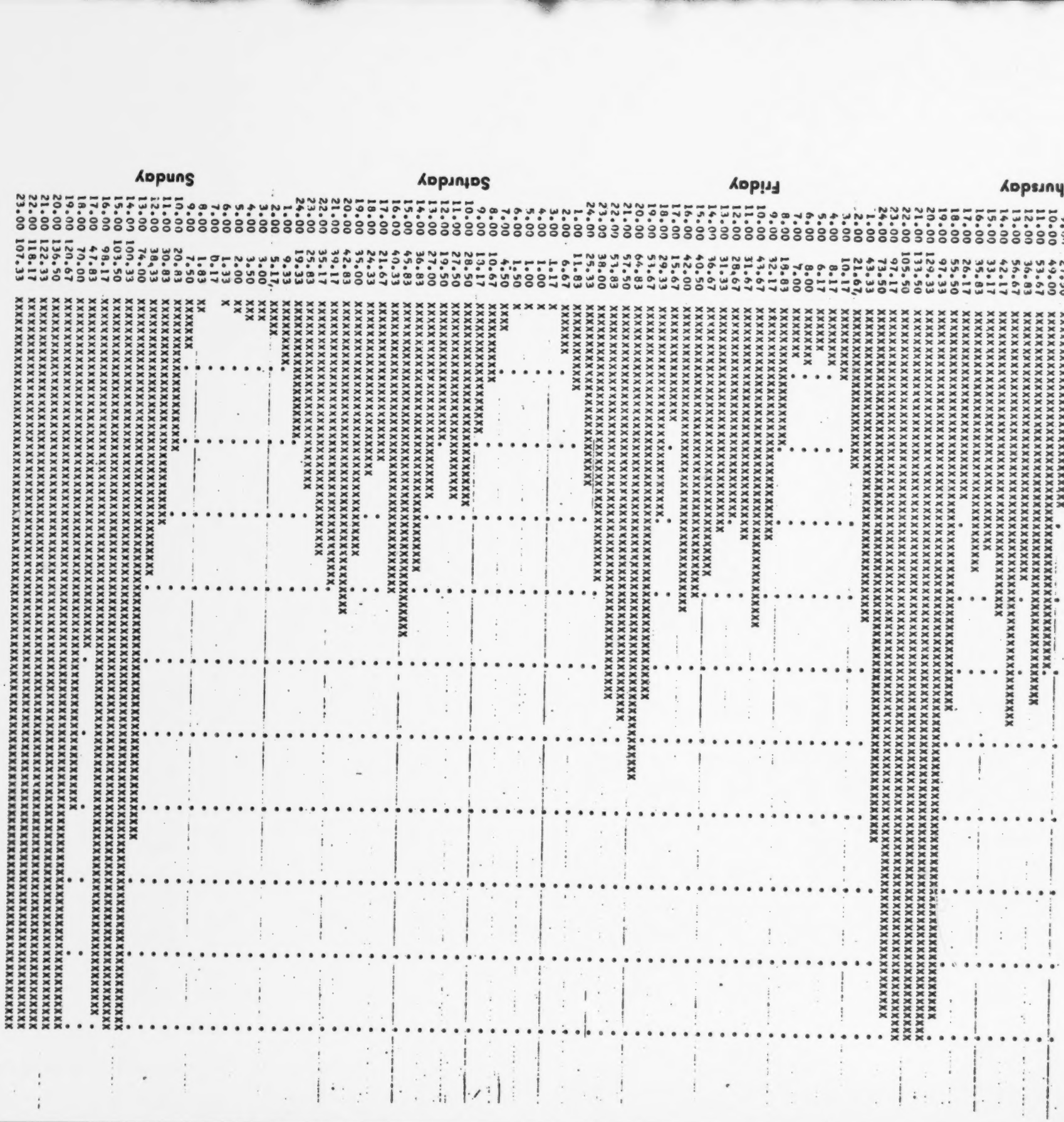

Thursday
Friday
Saturday
Sunday

Figure 1.13: *Tally of Man-hours Devoted to Activities by Hour*

TALLY OF MAN-HOURS DEVOTED TO ACTIVITIES BY HOUR - EFL PROJECT LECTURE

MONDAY

HOUR	MAN-HRS
24.00	0.0
1.00	0.0
2.00	0.0
3.00	0.0
4.00	0.0
5.00	0.0
6.00	0.0
7.00	0.33
8.00	62.17
9.00	103.83
10.00	118.00
11.00	117.83
12.00	90.50
13.00	46.83
14.00	89.83
15.00	25.83
16.00	22.50
17.00	4.17
18.00	6.00
19.00	10.00
20.00	7.67
21.00	4.33
22.00	0.67
23.00	0.0

TUESDAY

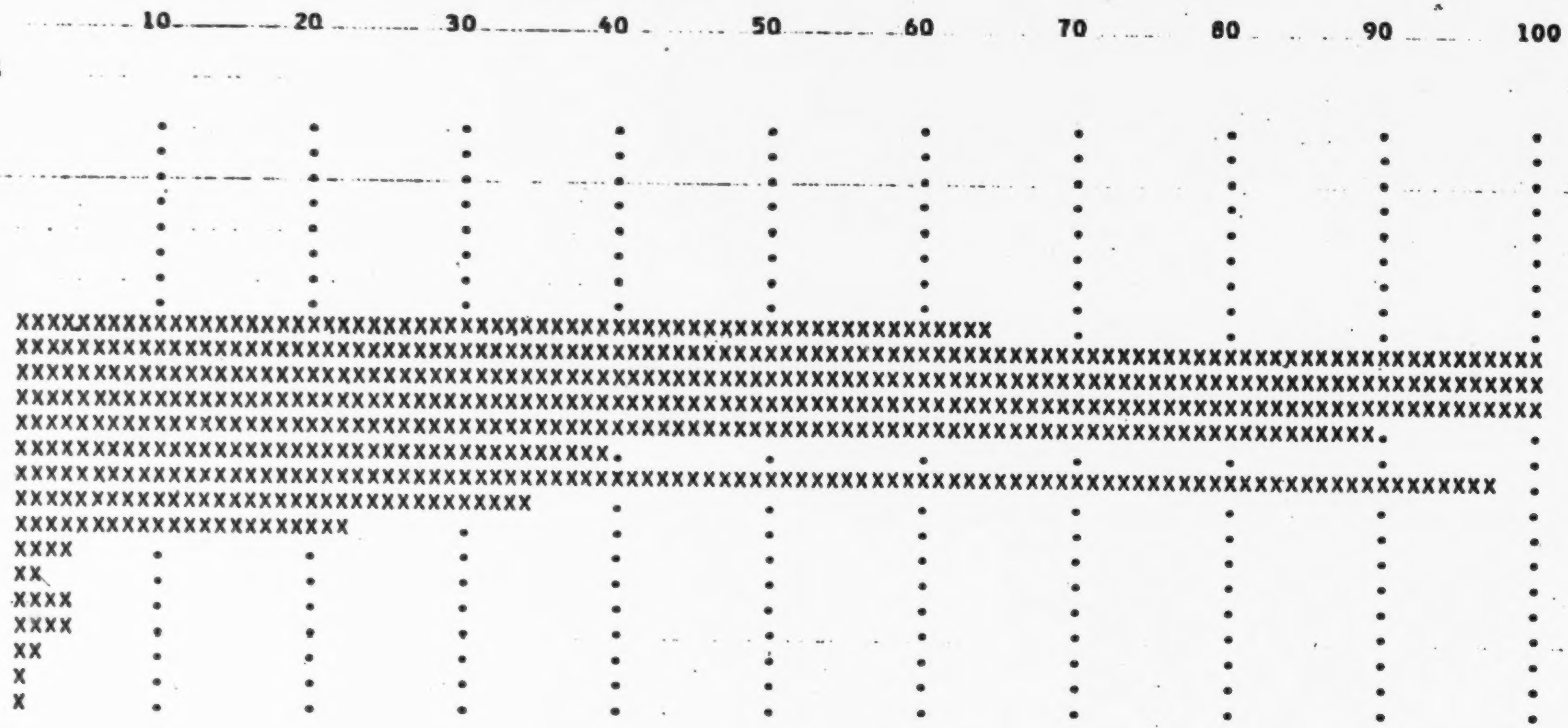
HOUR	MAN-HRS
24.00	0.0
1.00	0.0
2.00	1.00
3.00	0.0
4.00	0.0
5.00	0.0
6.00	0.0
7.00	0.33
8.00	71.17
9.00	92.17
10.00	86.33
11.00	81.00
12.00	57.83
13.00	19.00
14.00	77.83
15.00	34.67
16.00	16.17
17.00	1.67
18.00	4.33
19.00	11.67
20.00	12.67
21.00	6.50
22.00	3.33
23.00	0.83

TALLY OF MAN-HOURS DEVOTED TO ACTIVITIES BY HOUR - EFL PROJECT

LECTURE

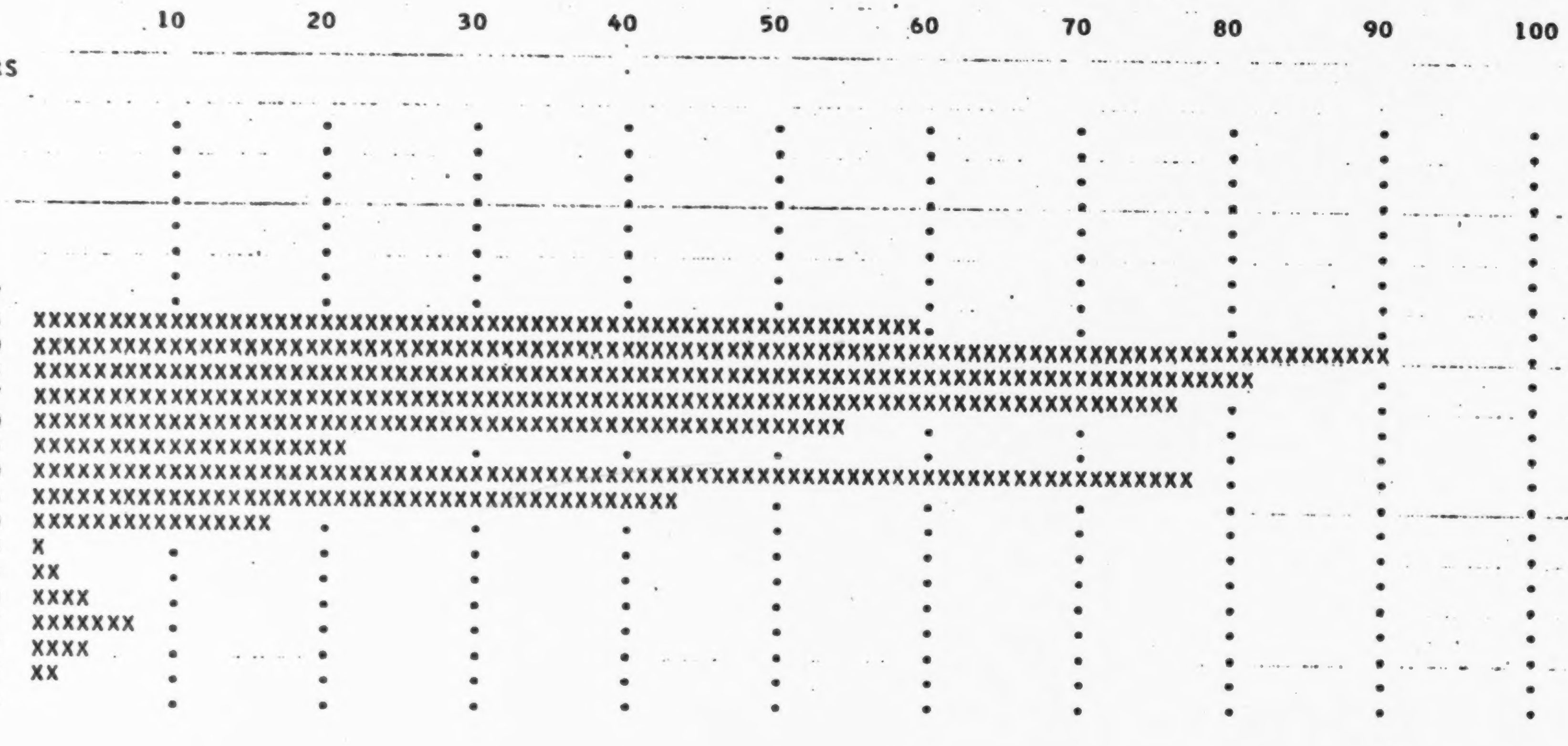
WEDNESDAY

HOUR	MAN-HRS
24.00	0.0
1.00	0.0
2.00	0.0
3.00	0.0
4.00	0.0
5.00	0.0
6.00	0.0
7.00	0.0
8.00	64.17
9.00	104.17
10.00	115.67
11.00	111.83
12.00	88.67
13.00	39.33
14.00	96.83
15.00	33.67
16.00	22.00
17.00	4.50
18.00	2.33
19.00	4.33
20.00	4.00
21.00	2.33
22.00	1.00
23.00	1.33



THURSDAY

HOUR	MAN-HRS
24.00	0.0
1.00	0.0
2.00	0.0
3.00	0.0
4.00	0.0
5.00	0.0
6.00	0.0
7.00	0.17
8.00	59.33
9.00	90.00
10.00	81.33
11.00	75.67
12.00	54.00
13.00	20.83
14.00	77.00
15.00	42.83
16.00	16.00
17.00	1.33
18.00	1.83
19.00	4.50
20.00	7.17
21.00	4.17
22.00	1.67
23.00	0.33



TALLY OF MAN-HOURS DEVOTED TO ACTIVITIES BY HOUR - EFL PROJECT

LECTURE

FRIDAY

HOUR	MAN-HRS
24.00	0.50
1.00	0.0
2.00	1.00
3.00	0.0
4.00	0.0
5.00	0.0
6.00	0.0
7.00	0.0
8.00	57.00
9.00	102.33
10.00	94.83
11.00	88.83
12.00	72.67
13.00	29.17
14.00	49.33
15.00	20.17
16.00	12.67
17.00	0.67
18.00	0.50
19.00	1.50
20.00	2.00
21.00	2.50
22.00	1.00
23.00	0.67

SATURDAY

HOUR	N-HRS
24.00	0.0
1.00	0.0
2.00	0.0
3.00	0.0
4.00	0.0
5.00	0.0
6.00	0.0
7.00	0.17
8.00	26.17
9.00	50.83
10.00	42.83
11.00	31.83
12.00	20.67
13.00	3.17
14.00	4.83
15.00	3.33
16.00	3.83
17.00	1.17
18.00	0.0
19.00	0.0
20.00	0.0
21.00	0.0
22.00	0.0
23.00	0.0

TALLY OF MAN-HOURS DEVOTED TO ACTIVITIES BY HOUR - EFL PROJECT

LECTURE

SUNDAY HOUR	MAN-HRS	10 ... 20 ... 30 ... 40 ... 50 ... 60 ... 70 ... 80 ... 90 ... 100
24.00	0.0	
1.00	0.0	
2.00	0.0	
3.00	0.0	
4.00	0.0	
5.00	0.0	
6.00	0.0	
7.00	0.0	
8.00	2.67	XXX
9.00	3.00	XXX
10.00	3.50	XXX
11.00	3.83	XXXX
12.00	3.33	XXX
13.00	0.50	X
14.00	0.0	
15.00	0.0	
16.00	0.0	
17.00	0.0	
18.00	0.50	X
19.00	0.50	X
20.00	0.83	X
21.00	0.17	
22.00	1.00	X
23.00	0.83	X

Figure 1.14 is an overlay to the campus map of Duke and shows the traffic generated by students as they moved from building to building during the week. Since the records in the diary are recorded sequentially, trips from building to building can be traced and summarized. The actual paths or routes taken by the students are not shown; straight lines between facilities are shown. The width of the band is proportional to the volume of traffic. Figure 1.15 is another overlay to the map and shows the relative time spent in each building. The area of the circle is proportional to the total student time spent in that facility.

These plots were produced by a mechanical plotter (CalComp) driven by a computer generated magnetic tape. That tape was generated by processing the diary tape and summarizing trips and time spent in the various buildings.

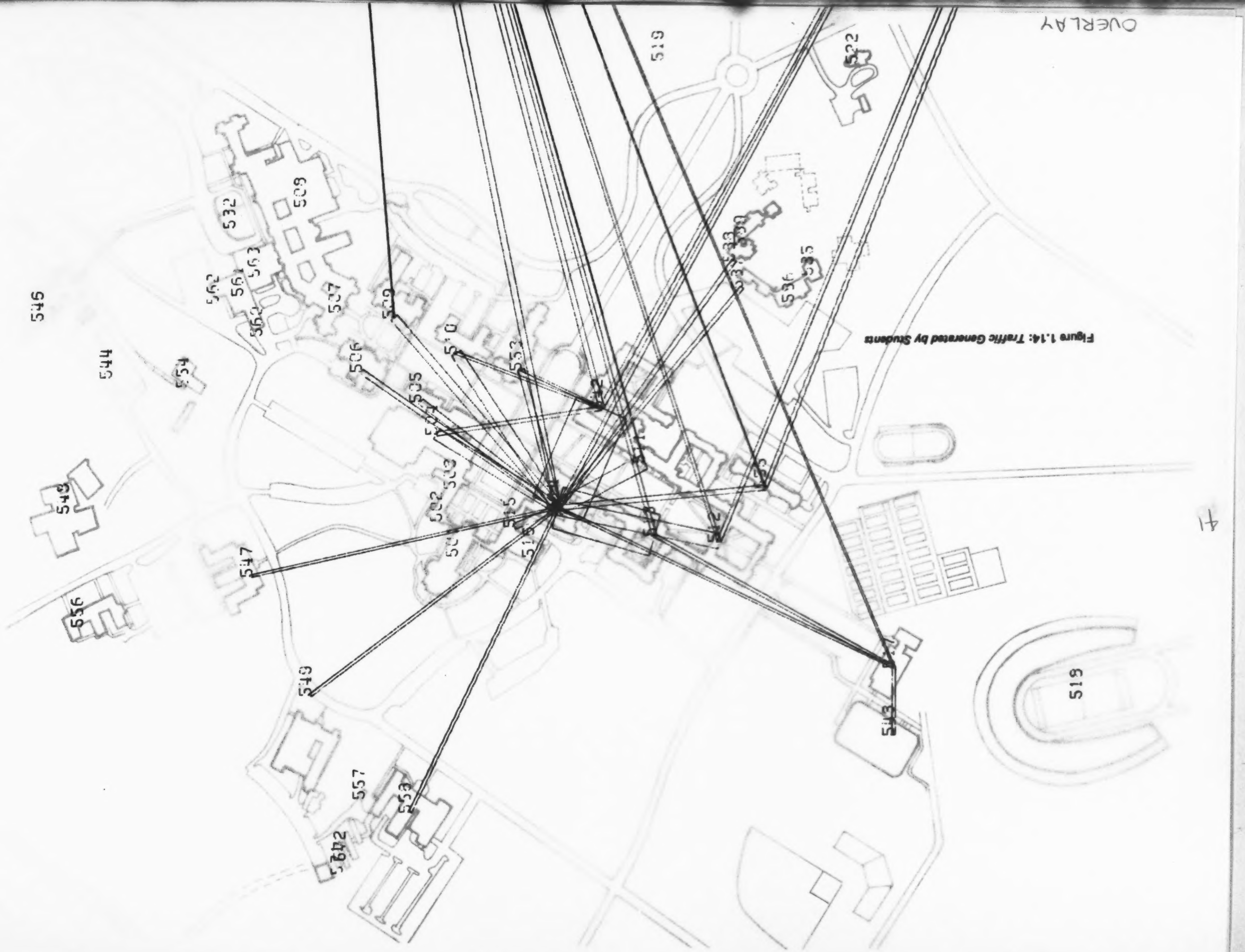


Figure 1.14: Traffic Generated by Students

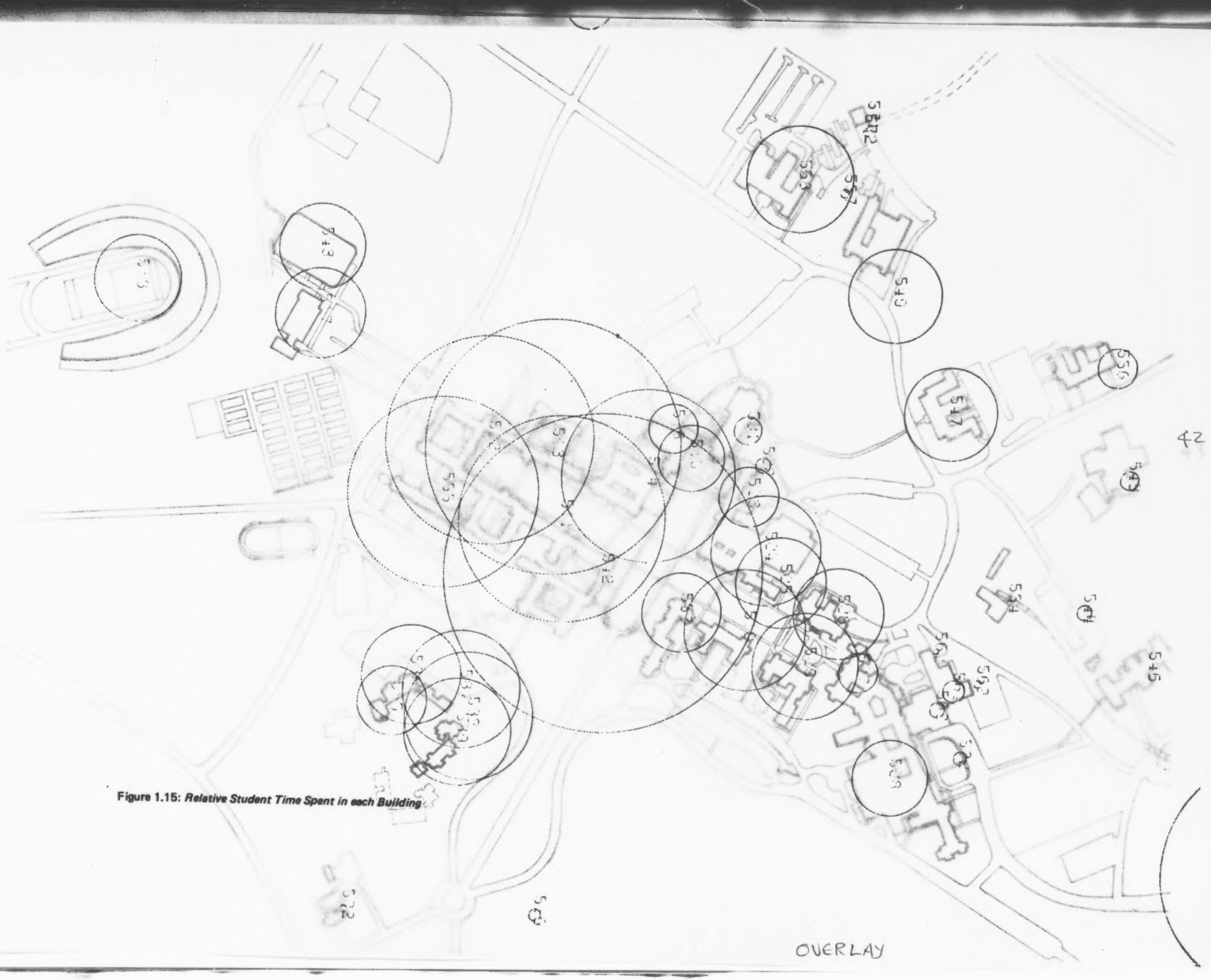


Figure 1.15: ***Relative Student Time Spent in each Building***

BUILDING PLAN EVALUATION

Program objective

The purpose of planning is to determine the most appropriate course of actions which will most nearly achieve a set of objectives with the resources available. It is assumed that the planning process is rational and consists of several steps. These steps are not always clearly defined: planning functions often overlap; information is fed back during the process and may require review and repetition of earlier steps. The suggested process is described in Figure 1.3 and consists of the following steps:

- Definition of Goals
- Collection of Facts & Policies
- Analysis of Facts & Policies
- Projection of policies and significant planning data
- Syntheses of the information into alternative plans of action
- Evaluation of the Alternative Plans
- Selection of a Plan
- Implementation of that Plan

Large volumes of data are involved in most planning problems. Many ramifications result from the use of that mass of data. Therefore, it is often desirable to study alternative courses of action before selecting one course to implement. Computers can handle vast quantities of information swiftly and accurately and can enable the planner to investigate more alternative plans than other means presently permit.

The method suggested here proposes to evaluate alternative plans which might be proposed during the planning process. To be useful to the campus planner, evaluation techniques must provide information about the benefits, costs and timing implied in the actions specified by a plan. It is desirable, then, to simulate the execution of these actions and to observe the probable results before choosing one plan over another. The closer simulation can be made to represent the actions of the real world, the greater confidence the planner can have in the evaluation information.

Moreover, if several plans can be simulated in a short period of time and the results clearly displayed, the planner has improved the basis for selecting courses of action. It is for this reason, rapid, repetitive simulation of alternative plans involving large quantities of data, that the computer becomes an important planning tool. The following section explains a proposed method which implements the evaluation process through the use of a computer program.

This computer program system accepts data which describes the institution in terms of its activities and space relationships, simulates the growth of the activities over a specified period of time and displays the effects achieved by the use of alternative actions to accommodate and foster the growth.

Growing activities produce pressures upon space to which they are assigned and the planner must act wisely to alleviate such pressures. The institution can build new space, improve existing space, reassign space to different activities or demolish space completely. Over a period of years, there may be many alternative sets of actions which the institution may take to alleviate pressures on space. Development of this computer program is directed toward planning

that sequence of actions which enables the institution to employ its resources most effectively. The program brings together the information generated through fact finding analysis and projection of resources performed earlier in the planning process. Input information consists of data about activities, space, money and the characteristics which describe their relationships.

The program projects the quantities of activities over a period of time, and the pressures on space and conditions of the interactivity relationships are reported to the planner. A dialogue ideally takes place between the program and the planner, in that the latter responds to the pressures described by the program by specifying which actions he thinks are appropriate to execute. Constraints having been placed on these actions, the program executes the actions and reports the resulting changes in the use of institutional resources.

Input data

In the first phase of the evaluation program, various planning data are supplied as input. This section outlines the basic data requirements to describe the institutional resources in terms of activities, space and money.

Cycle: The basic time period for simulation is called a cycle here. The cycle may be defined for the convenience of the institutional planner and most often will correspond to the budgeting period.

Money: For each planning cycle which the institution wishes to study, capital funds available for the construction are provided as input. Additionally, unit costs per square foot for maintenance, renovation and new construction are entered by space type for each cycle under investigation. Later in the program maintenance costs for each existing space type are calculated. Spaces that are renovated are costed at the unit cost provided here; new space is estimated at the unit construction cost provided here.

Activities: Activities are defined as those human or mechanical functions which generate needs for space. Examples of activities are: Humanities Lecture, Science Laboratory, Engineering Research, Residential, Study, General Administration, Auxiliary Enterprises or Public Activities. Each of the activities defined in the institution is named and a quantity of that activity is input data at the base point in time for planning. The maximum utilization, minimum utilization and utilization at base time, are given. Quantities of activities may be measured in numbers of people, hours of activity, research units or other units of measure appropriate to that activity. Utilization is a relationship of the quantity of activity to the quantity of space assigned to it. The minimum and maximum utilizations are constraints imposed by the planner and are the bounds within which the program seeks to maintain the relationship of activity and space. The base utilization is the current estimate or the known utilization at the starting point of the study. A growth ratio is associated with each activity from which the quantity of that activity can be calculated at future cycles. These growth ratios are step functions and are supplied as input data.

Space Assignments: The campus is zoned geographically and each zone is numbered for identification. Within each zone, space is assigned to the activities which occur in that zone. Space is assigned by space type and quantity. A net to gross ratio permits the net area to be transformed to gross area assigned to that activity.

Zone Density: For each zone identified on the campus the maximum space permitted to be constructed in that zone is provided as input. The amount of vacant (unassigned space) by space type in each zone is also input information.

Interzone Distances: Distance, as used in this program, may be either distance measured in linear feet between centers of activities of geographic zones or travel time in minutes between the same centers of activity.

Interactivity Affinity: Affinity here is described as the attraction or repulsion between one activity and another activity. The definition of activities must be appropriate to the institution being studied. In general, activities may range from lecture, laboratory and other regulary scheduled academic activities, to such activities as recreation, dining, eating and community activities. At this point, hard data on affinity relationship may be difficult to acquire. One source of academic inter-relationship can be obtained from the number of credit hours or contact hours of instruction provided by one activity to each of the other academic activities. Other values can be obtained by surveying the hours various kinds of students, faculty and staff spend in the use of various facilities, such as the library, student union and dormitories. Further investigation to define affinities could involve studies of interdepartmental research or joint use of various space types, or perhaps the department or administrative desires for one activity to be associated with another activity.

Measure of Effectiveness: The measure suggested here is one indication of the total effectiveness of a plan in using institutional resources. It is this measure of effectiveness which the planner and administrator attempt to optimize through the execution of proper actions over time. Currently there are three considerations involved in this measure.

- *Assignment of space to activities* in zones in order to best satisfy interactivity affinity. The objective is to assign space to activities, such that the distances between activities having high affinities to one another are minimum. Conversely, those activities which have low or even negative affinity to one another, shall be located as separate from one another as is practicable.

- *Maintaining of desired density levels* within zones by zone type. Desired density is expressed as a percent of maximum allowable density within a zone. Control of density will increase the measure of effectiveness. Considering density levels by zone type enhances the flexibility of the measure of effectiveness by permitting the planner to specify a given zone type as more sensitive to density consideration or crowding than another zone type. Zones may currently be specified as *central, secondary* or *remote.* The definition of central, secondary and remote may be tailored to the planning goals. They need not necessarily specify geographic location, but may be used to define zones by building density. For example, *central* could be taken to mean the zone in which it is desirable that there be a greater building

density than in any other zone or class of zones. *Secondary* might be taken to mean those zones in which it is more desirable to have sparse building density. Thirdly, *remote* might be defined as those zones in which there is presently little (or it is deemed desirable that there be little) building density. In essence, there are simply three relative densities, one of which should be assigned to each zone.

- *Control of utilization* for a given activity as related to the space occupied by that activity within the zone by zone type. A criterion for realizing the plan which is considered ideal is to have the space needs of each activity satisfied throughout the run. The degree to which the execution of projects satisfies these requirements is scored by the measure of effectiveness.

Program procedure

One of the objectives in the use of this program is to demonstrate the dialogue which is possible between planner and computer. It is not intended that any computer program can or should make decisions which are unrelated to the reality of the campus situation. The role of this computer program or others like it is to display the status of the campus activity-space-money relationships and the results or implications of taking various actions which the planner may propose in order to assist the decision making process. The approach has been to simulate the growth of activities through a given number of cycles. The growth of these activities produces pressures on the resources of space and money. The planner designs *projects,* consisting of various sets of *actions,* to alleviate these pressures. These projects are provided as data and together describe a *plan* of action. The program is run in order to simulate the execution of the actions and projects, to note the consumption of resources and the resulting effects on the measure of effectiveness.

If the actions taken in one sequence for a given plan do not completely satisfy the planner, he may design alternate plans consisting of different sets of projects. The objective of such sequential studies is to find which set of projects executed in which order produces the greatest increase in effectiveness per dollar expended.

Sample output

These comments refer to sample output which follows.

Space Assignments: Each activity is identified by an index number and a name such as humanities lecture, humanities lab, humanities officing and research, etc. The zone is identified by number within which the space is assigned. Each type of space assigned is identified by a code number and name, such as class (for classroom), general support, lab, special, office, etc. The net square feet assigned to that activity in that zone by space type is noted. In several instances, multiple entries for a space type within a zone to the same activity can be noted; this multiple assignment results from summarizing areas from different buildings within that same zone.

Summary of Total Space assigned to an activity by space type: From the many space assignments to activities noted above, a summary table is generated showing for each activity the total space assigned to that activity by space types, such as classroom, lab, office, study, etc.

Interzoned distances: The numbers beneath the titles "OF" and "TO" indicate the distances *from* a zone *to* each of the other zones. In the first column, the distance from zone 1 to zone 2 is 538 units. The units in this case were taken as straight line linear feet. The intrazone distance it will be noted is always 1. An average walking distance within that zone could be entered instead. The distance from zone 1 to zone 11 is 2,366 feet.

Interactivity affinities: The values suggested here lie between 0 and 1. The affinity between an activity and itself is 1.

In the example, the affinity between activity 1 and activity 16 is .10.

Growth ratios by cycles: These ratios are input data and are listed here for verification. The ratios shown for each cycle are the growth anticipated in relation to the base data at time zero. Thus, humanities lecture is expected to be 10% greater in cycle 1 than at base time, 35% greater in cycle 2, and 65% greater in cycle 3.

Utilization report: For each activity the minimum and maximum utilization limits are listed, together with the current activity level and the current utilization. The total area assigned to the activity is also listed. As base input the currect utilization is given; using that basic utilization, a relationship is established between activity and total area which is used thereafter to calculate the current utilization.

Square feet assigned by space type within zone: For each zone the area assigned to all activities is summarized by space type. A zone total is given as is the maximum area permitted within that zone.

Square feet of vacant space by type within zone: For each zone the area which is vacant or unassigned to an activity is noted by kind of space. A total is given for each zone, which summarizes all kinds of space types.

Measure of Effectiveness for a Plan and a Cycle of Investigation: The measure of effectiveness in this example is 59.15. At this point, the measure reflects the initial status of campus. It is this measure that we wish to improve through the use of our resources simulated to the execution of projects.

Plan 1, Cycle 1

For this cycle, the funds available for contruction are $10,000,000. The activities are noted by name and the level of activity. In this case Humanities Lecture is represented by 20,209 clock hours of instruction.

Critical activities (utilization): Each activity for which the current utilization lies outside the bounds of maximum or minimum utilization, the following factors are listed: activity identified by code and name, current utilization, maximum utilization, minimum utilization, a priority index, an area for minimum utilization and an area for maximum utilization.

The priority index is a composite number representing 1) the degree to which the current utilization lies outside the bounds specified by the planner and 2) the amount of activity

involved. Therefore, if two activities exceed the maximum utilization by the same degree, the activity with the greater amount of activity would rank higher in priority for attention than would the other activity. Areas are calculated and displayed which would be required to bring the utilization to a minimum or to a maximum level for that activity. The project to be described or suggested for that activity probably lies somewhere between these two areas.

Critical Activities (No Space): Activities would be listed in this section during some cycle in which a new activity was created but for which no space was provided.

Critical Activities (Space Condition): If the space assigned to activities is linked to the current space inventory of the institution, space condition could be reported and could cause an activity to become critical. This condition could indicate the need for renovation or demolition of that space. The activities involved are indicated.

Critical Zones: (Density) A maximum allowable area for each zone has been provided as input. When the current area assigned in that zone exceeds the allowable area, the zone is said to be critical. The information displayed is the zone identification the current area in that zone, the area allowable for that zone, the excess and the activities in the area assigned to those activities which reside in that zone. From this information, if space is to be demolished, those activities which are likely to be effected are known.

Projects

A project is comprised of a set of actions. The actions available to the planner are: to *add* space, which indicates the assignment of space to activities; to *build* space, which means creating new space on the campus; to *demolish* space, which means removing space from the inventory; to *subtract* space or unassign space from an activity; or to *improve* space by means of renovation. A set of these actions comprises a project. Additional constraints on the execution of the project are 1) the earliest and latest cycles within which the project may be executed and 2) the availability of capital funds for such actions. In the first example in the sample output, Plan 1, Cycle 1, Project 1, the earliest cycle is cycle 1 and the latest cycle is cycle 4, in which the project could be executed. The cycle is critical and one of the activities listed is also critical. We see that activity 15 "Residential" in zone 57, a quantity of 19,287 square feet was to be destroyed for a lump sum of $12,500. The utilization after that action, which removed space from the assignment to residential activities, has been recalculated at 1.036. Similar actions are executed within that project. Project 2, Cycle 1, is not critical. Other projects are shown in the sample. Following the execution of these projects, which have affected density, proximity and utilization, the new measure of effectiveness is shown to be 63.66, an improvement over the original measure of 59.15. A summary for Cycle 1 is shown. Funds available, the costs of that cycle and the remaining balance are indicated. Maintenance costs for Cycle 1 for each space type show the quantity of that space type and the unit cost for maintaining that kind of space. Total costs of the space type and for the institution are shown. The summary continues to show the activities which remain critical, by

reason of utilization, no space condition, or critical zones.

The plan continues with activities growth being simulated through each cycle and projects being executed as appropriate when activities are critical and funds are available. At a completion of the simulation of a plan, a summary of the condition of this institution at that point is given. The first aspect of the summary is to show in which cycle each project was executed. In the sample, Projects 1, 3, and 5 are executed in Cycle 1, Projects 3 and 4 in Cycle 2, and no projects in Cycle 3. Reports in the same format as the base data are provided, showing the utilization levels for each activity, the area assigned by space type to zones, the unassigned space to zone by space type, and the measure of effectiveness at the end of the plan. Additionally critical activities and zones are displayed. A summary of construction costs, renovation costs and maintenance costs are shown as the final output.

EVALUATION STUDY FOR PROPOSED CAMPUS PLANS
A PROJECT SPONSORED BY EDUCATIONAL FACILITIES LABORATORIES, DUKE UNIVERSITY, AND CAUDILL ROWLETT SCOTT

INITIAL DATA FOR PLAN 1

CYCLE	CAPITAL FUNDS
1	10000000.
2	15000000.
3	20000000.

SPACE ASSIGNMENTS

ACTIVITY		ZONE	SPACE TYPE		NET SQUARE FEET
1	HUM LECT	7	1	CLASS	1178.
1	HUM LECT	19	1	CLASS	420.
1	HUM LECT	19	1	CLASS	1576.
1	HUM LECT	19	1	CLASS	4344.
1	HUM LECT	19	1	CLASS	391.
1	HUM LECT	19	1	CLASS	680.
1	HUM LECT	19	1	CLASS	1002.
1	HUM LECT	19	1	CLASS	3368.
1	HUM LECT	19	1	CLASS	1415.
1	HUM LECT	19	1	CLASS	45.
1	HUM LECT	19	6	GENERAL	312.
1	HUM LECT	19	6	GENERAL	1751.
1	HUM LECT	19	7	SUPPORT	760.
1	HUM LECT	19	7	SUPPORT	40.
1	HUM LECT	19	7	SUPPORT	48.
1	HUM LECT	19	7	SUPPORT	106.
1	HUM LECT	19	7	SUPPORT	63.
1	HUM LECT	23	6	GENERAL	183.
1	HUM LECT	30	1	CLASS	1873.
1	HUM LECT	31	1	CLASS	3441.
1	HUM LECT	31	1	CLASS	2597.
1	HUM LECT	47	1	CLASS	2163.
1	HUM LECT	47	1	CLASS	1275.
1	HUM LECT	47	1	CLASS	1621.
1	HUM LECT	47	1	CLASS	94.
1	HUM LECT	47	6	GENERAL	389.
1	HUM LECT	47	6	GENERAL	4559.
1	HUM LECT	47	7	SUPPORT	1053.
1	HUM LECT	47	7	SUPPORT	168.
1	HUM LECT	47	7	SUPPORT	360.
1	HUM LECT	52	1	CLASS	1714.
1	HUM LECT	52	1	CLASS	1512.
1	HUM LECT	52	1	CLASS	348.
1	HUM LECT	52	6	GENERAL	437.
1	HUM LECT	53	1	CLASS	1523.
1	HUM LECT	53	1	CLASS	1741.
1	HUM LECT	53	1	CLASS	452.
1	HUM LECT	53	1	CLASS	1238.
1	HUM LECT	53	1	CLASS	2450.
1	HUM LECT	53	1	CLASS	38.
1	HUM LECT	53	7	SUPPORT	14.
1	HUM LECT	59	6	GENERAL	1744.
2	HUM LAB	7	2	LAB	11079.
2	HUM LAB	19	2	LAB	1694.
2	HUM LAB	19	5	SPECIAL	133.
2	HUM LAB	19	5	SPECIAL	1966.
2	HUM LAB	19	5	SPECIAL	553.
2	HUM LAB	47	2	LAB	451.
2	HUM LAB	47	2	LAB	5739.
2	HUM LAB	47	2	LAB	598.
2	HUM LAB	47	2	LAB	1884.
2	HUM LAB	47	2	LAB	376.
2	HUM LAB	53	2	LAB	837.
2	HUM LAB	53	2	LAB	1265.
2	HUM LAB	55	2	LAB	6694.
3	HUM O/R	7	3	OFFICE	5801.

SUMMARY OF TOTAL SPACE ASSIGNED TO AN ACTIVITY BY SPACE TYPE

	ACTIVITY	CLASS	LAB	OFFICE	STUDY	SPECIAL	GENERAL	SUPPORT	HOUSING	FOOD	ATHLETIC	TOTAL
1	HUM LECT	38299.	0.	0.	0.	0.	9375.	2652.	0.	0.	0.	50326.
2	HUM LAB	0.	30617.	0.	0.	2652.	0.	0.	0.	0.	0.	33269.
3	HUM O/R	0.	0.	51053.	0.	545.	466.	0.	0.	0.	0.	52064.
4	S S LCT	31876.	0.	0.	0.	0.	7563.	12207.	0.	0.	0.	51646.
5	S S LAB	0.	19250.	0.	0.	0.	0.	0.	0.	0.	0.	19250.
6	S S O/R	0.	0.	49161.	0.	2435.	0.	0.	0.	0.	0.	51596.
7	SCI LCT	21059.	0.	0.	0.	0.	5008.	23901.	0.	0.	0.	49968.
8	SCI LAB	0.	139457.	0.	0.	0.	0.	0.	0.	0.	0.	139457.
9	SCI RSCH	0.	625.	0.	0.	1758.	0.	2184.	0.	0.	0.	4567.
10	SCI OFF	0.	0.	45692.	0.	0.	0.	1407.	0.	0.	0.	47099.
11	ENG LCT	4130.	0.	0.	0.	0.	0.	3419.	0.	0.	0.	7549.
12	ENG LAB	0.	22658.	0.	0.	0.	0.	0.	0.	0.	0.	22658.
13	ENG RSCH	0.	0.	0.	0.	255.	0.	0.	0.	0.	0.	255.
14	ENG OFF	0.	0.	9313.	0.	0.	0.	0.	0.	0.	0.	9313.
15	RESDENTL	0.	0.	12388.	1898.	0.	29349.	16414.	408419.	84303.	0.	552771.
16	STUDY	0.	0.	0.	69746.	0.	0.	0.	0.	0.	0.	69746.
17	RECRTN I	4670.	0.	9050.	328.	0.	1072.	3527.	1215.	0.	58802.	78664.
18	RECRTN O	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19	GEN ADMN	6109.	0.	87625.	1616.	5039.	45754.	79146.	181.	3292.	39927.	268689.
20	AUXLRY	0.	37.	16600.	2888.	0.	2038.	3799.	17403.	2482.	0.	45247.
21	PUBLIC	0.	0.	18446.	137.	0.	5021.	0.	0.	0.	0.	23604.
	TOTALS	106143.	212644.	299328.	76613.	12684.	105646.	148656.	427218.	90077.	98729.	1577738.

INTERZONE DISTANCES

FROM	TO	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10
1	1	1.00	538.00	1077.00	1543.00	2130.00	2126.00	1720.00	999.00	783.00	559.00
1	11	2366.00	1589.00	1449.00	1822.00	2446.00	2810.00	2710.00	3167.00	2893.00	2425.00
1	21	2031.00	1758.00	2121.00	2075.00	2358.00	2356.00	[illegible]3.00	2675.00	2858.00	3083.00
1	31	3214.00	3383.00	2617.00	3467.00	3991.00	4401.00	[illegible]02.00	5826.00	6831.00	7600.00
1	41	8403.00	8831.00	9058.00	9231.00	9360.00	9502.00	9897.00	9669.00	9663.00	9465.00
1	51	9489.00	9914.00	10031.00	10120.00	10373.00	10696.00	10581.00	10435.00	10250.00	10159.00
1	61	3747.00	3041.00	3504.00	3473.00	4005.00	4885.00	5124.00	5125.00		

FROM	TO	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10
2	1	538.00	1.00	538.00	1006.00	1601.00	1664.00	1300.00	650.00	614.00	807.00
2	11	2573.00	1655.00	1206.00	1475.00	2113.00	2372.00	2311.00	2809.00	2581.00	2152.00
2	21	1775.00	1583.00	2185.00	1947.00	2261.00	2174.00	2350.00	2530.00	2664.00	2826.00
2	31	2921.00	3059.00	2529.00	3359.00	3901.00	4242.00	4713.00	5635.00	6628.00	7410.00
2	41	8203.00	8666.00	8787.00	8907.00	9018.00	9140.00	9535.00	9334.00	9344.00	9163.00
2	51	9234.00	9615.00	9715.00	9788.00	10028.00	10357.00	10253.00	10125.00	9955.00	9892.00
2	61	3375.00	2549.00	3030.00	3042.00	3558.00	4436.00	4691.00	4655.00		

FROM	TO	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10
3	1	1077.00	538.00	1.00	471.00	1081.00	1264.00	1000.00	654.00	850.00	1253.00
3	11	2868.00	1880.00	1179.00	1270.00	1677.00	1984.00	1981.00	2515.00	2352.00	1990.00
3	21	1660.00	1582.00	2373.00	1963.00	2289.00	2117.00	2213.00	2495.00	2569.00	2655.00
3	31	2704.00	2801.00	2555.00	3335.00	3883.00	4148.00	4579.00	5491.00	6463.00	7256.00
3	41	8035.00	8532.00	8542.00	8604.00	8695.00	8795.00	9190.00	9018.00	9047.00	8884.00
3	51	9005.00	9337.00	9420.00	9474.00	9701.00	10035.00	9943.00	9835.00	9681.00	9646.00
3	61	3054.00	2080.00	2581.00	2651.00	3141.00	4019.00	4283.00	4201.00		

FROM	TO	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10
4	1	1543.00	1006.00	471.00	1.00	618.00	950.00	850.00	897.00	1179.00	1656.00
4	11	3115.00	2104.00	1270.00	1179.00	1700.00	1644.00	1700.00	2253.00	2158.00	1878[illegible]
4	21	1615.00	1646.00	2546.00	2015.00	2334.00	2095.00	2113.00	2476.00	2494.00	2506.[illegible]
4	31	2510.00	2567.00	2586.00	3301.00	3845.00	4038.00	4430.00	5323.00	6272.00	7070.00
4	41	7834.00	8360.00	8276.00	8290.00	8364.00	8446.00	8841.00	8693.00	8736.00	8589.00
4	51	8750.00	9042.00	9111.00	9150.00	9366.00	9703.00	9621.00	9529.00	9388.00	9378.00
4	61	2755.00	1656.00	2169.00	2291.00	2753.00	3614.00	3895.00	3777.00		

FROM	TO	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10
5	1	2130.00	1601.00	1081.00	618.00	1.00	656.00	877.00	1323.00	1637.00	2160.00
5	11	3384.00	2383.00	1480.00	1185.00	1495.00	1187.00	1337.00	1882.00	1891.00	1750.00
5	21	1608.00	1773.00	2743.00	2091.00	2379.00	2070.00	1981.00	2429.00	2371.00	2281.00
5	31	2225.00	2221.00	2601.00	3202.00	3725.00	3820.00	4152.00	5013.00	5924.00	6725.00
5	41	7467.00	8025.00	7829.00	7791.00	7846.00	7909.00	8303.00	8181.00	8238.00	8109.00
5	51	8316.00	8561.00	8614.00	8637.00	8841.00	9181.00	9111.00	9035.00	8910.00	8926.00
5	61	2313.00	1068.00	1589.00	1779.00	2195.00	3037.00	3328.00	3176.00		

FROM	TO	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10
6	1	2126.00	1664.00	1264.00	950.00	656.00	1.00	447.00	1152.00	1450.00	1983.00
6	11	2885.00	1927.00	1044.00	626.00	840.00	719.00	751.00	1305.00	1[illegible]3.00	1096.00
6	21	998.00	1234.00	2207.00	1502.00	1767.00	1436.00	1325.00	1785.00	1[illegible]15.00	1634.00
6	31	1597.00	1627.00	1972.00	2546.00	3069.00	3176.00	3528.00	4406.00	5339.00	6139.00

INTERACTIVITY AFFINITIES

BETWEEN	AND	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10
1	1	1.00	.50	.50	.90	.00	.00	.40	.00	.00	.00
1	11	.55	.00	.00	.00	.50	.10	.00	.00	.00	.00
1	21	.00									

BETWEEN	AND	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10
2	1	.50	1.00	1.00	.00	.00	.00	.40	.00	.00	.35
2	11	.45	.00	.00	.00	.50	.10	.00	.00	.00	.00
2	21	.00									

BETWEEN	AND	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10
3	1	.50	1.00	1.00	.00	.00	.50	.00	.00	.00	.85
3	11	.00	.00	.00	.25	.00	.00	.00	.00	.35	.40
3	21	.00									

BETWEEN	AND	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10
4	1	.90	.00	.00	1.00	.50	.50	.40	.00	.00	.65
4	11	.40	.00	.00	.30	.50	.10	.00	.00	.00	.00
4	21	.00									

BETWEEN	AND	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10
5	1	.00	.00	.00	.50	1.00	1.00	.00	.00	.00	.65
5	11	.40	.00	.00	.30	.50	.10	.00	.00	.00	.00
5	21	.00									

BETWEEN	AND	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10
6	1	.00	.00	.50	.50	1.00	1.00	.00	.00	.00	.20
6	11	.00	.00	.00	.00	.00	.00	.00	.00	.25	.40
6	21	.00									

BETWEEN	AND	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10
7	1	.40	.40	.00	.40	.00	.00	1.00	.80	.95	.35
7	11	.60	.00	.00	.60	.50	.10	.00	.00	.00	.00
7	21	.00									

BETWEEN	AND	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10
8	1	.00	.00	.00	.00	.00	.00	.80	1.00	.75	.25
8	11	.00	.00	.00	.00	.50	.10	.00	.00	.00	.00
8	21	.00									

BETWEEN	AND	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10
9	1	.00	.00	.00	.00	.00	.00	.95	.75	1.00	.85
9	11	.00	.00	.60	.00	.00	.00	.00	.00	.00	.00
9	21	.00									

BETWEEN	AND	*1	*2	*3	*4	*5	*6	*7	*8	*9	*10

GROWTH RATIOS BY CYCLE

	ACTIVITY	CYCLE 1	CYCLE 2	CYCLE 3	CYCLE
1	HUM LECT	1.100	1.350	1.650	
2	HUM LAB	1.100	1.350	1.650	
3	HUM O/R	1.200	1.600	2.000	
4	S S LCT	1.250	1.500	1.750	
5	S S LAB	1.250	1.500	1.750	
6	S S O/R	1.100	1.300	1.600	
7	SCI LCT	1.250	1.500	2.000	
8	SCI LAB	1.250	1.500	2.000	
9	SCI RSCH	1.200	1.400	1.600	
10	SCI OFF	1.200	1.400	1.600	
11	ENG LCT	1.050	1.100	1.150	
12	ENG LAB	1.050	1.100	1.150	
13	ENG RSCH	1.100	1.200	1.300	
14	ENG OFF	1.050	1.100	1.170	
15	RESDENTL	1.000	1.000	1.000	
16	STUDY	1.100	1.350	1.650	
17	RECRIN I	1.050	1.050	1.100	
18	RECRIN O	1.250	1.500	1.650	
19	GEN ADMN	1.100	1.250	1.500	
20	AUXLRY	1.050	1.100	1.200	
21	PUBLIC	1.050	1.100	1.200	

	ACTIVITY	MINIMUM UTILIZATION	MAXIMUM UTILIZATION	GROWTH RULE	ACTIVITY LEVEL	CURRENT UTILIZATION	TOTAL AREA
1	HUM LECT	.500	1.000	1	18372.	.950	50326.
2	HUM LAB	.400	1.000	2	6442.	.500	33269.
3	HUM O/R	.900	1.000	3	3278.	.920	52064.
4	S S LCT	.500	1.000	4	20361.	.800	51646.
5	S S LAB	.400	1.000	5	0.	.000	19250.
6	S S O/R	.900	1.000	6	2992.	.950	51596.
7	SCI LCT	.500	1.000	7	8272.	.500	49968.
8	SCI LAB	.400	1.000	8	8908.	.350	139457.
9	SCI RSCH	.500	1.000	9	1685.	1.100	4567.
10	SCI OFF	.900	1.000	10	845.	3.500	47099.
11	ENG LCT	.500	1.000	11	1114.	1.250	7549.
12	ENG LAB	.400	1.000	12	160.	.800	22658.
13	ENG RSCH	.350	1.000	13	572.	2.100	255.
14	ENG OFF	.900	1.000	14	286.	.950	9313.
15	RESDENTL	.750	1.000	15	300800.	1.000	552771.
16	STUDY	.850	1.000	16	111340.	.900	69746.
17	RECRTN I	.850	1.000	17	120100.	.900	78664.
18	RECRTN O	.850	1.000	18	199475.	.000	0.
19	GEN ADMN	.850	1.000	19	5000.	.900	268689.
20	AUXLRY	.500	1.000	20	3500.	.750	45247.
21	PUBLIC	.300	1.000	21	800.	.650	23604.

ZONE	SQUARE FEET ASSIGNED BY SPACE TYPE										ZONE TOTAL	ZONE MAX
	CLASS	LAB	OFFICE	STUDY	SPECIAL	GENERAL	SUPPORT	HOUSING	FOOD	ATHLETIC		
1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000
2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000
3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000
4	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000.
5	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000.
6	12196.	30458.	19485.	4822.	0.	642.	13444.	0.	0.	0.	81047.	1000000
7	4121.	94582.	22721.	5282.	366.	3770.	4733.	0.	0.	0.	135575.	1000000
8	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1000000
9	7088.	0.	12676.	32767.	0.	4677.	8939.	0.	0.	0.	66147.	1000000
10	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000
11	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1000000
12	1287.	0.	24843.	0.	927.	1072.	4984.	0.	186.	36870.	70169.	750000
13	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000
14	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000
15	0.	0.	296.	0.	0.	16337.	0.	0.	0.	0.	16633.	17000
16	9630.	22658.	11687.	5998.	255.	0.	4753.	0.	4[illegible].	0.	55399.	140000
17	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
18	4950.	25496.	4526.	1800.	0.	0.	10274.	0.	0.	0.	47046.	60000.
19	13241.	1694.	36479.	2126.	3188.	2741.	2942.	0.	130.	0.	62541.	66000.
20	0.	0.	8820.	0.	401.	6608.	513.	0.	2095.	2277.	20722.	110000.
21	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000.
22	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000.
23	2171.	0.	1900.	0.	0.	183.	967.	279.	0.	31490.	36990.	100000.
24	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
25	0.	0.	0.	0.	0.	3915.	0.	32767.	178.	0.	36460.	50000.
26	0.	0.	0.	0.	0.	1768.	0.	13041.	0.	0.	14809.	15000.
27	0.	0.	611.	0.	87.	14007.	7976.	50.	41264.	0.	69501.	125000.
28	0.	0.	1286.	0.	0.	8295.	0.	32767.	0.	0.	42348.	250000.
29	0.	0.	0.	0.	0.	0.	0.	7801.	0.	0.	7801.	60000.
30	5572.	0.	28703.	0.	0.	403.	7532.	0.	172.	0.	42382.	115000.
31	14079.	0.	12985.	0.	489.	1062.	301.	0.	77.	0.	28993.	115000.
32	5201.	18293.	11159.	0.	396.	2625.	2983.	0.	127.	0.	40784.	125000.
33	0.	0.	91.	0.	0.	1110.	2548.	32767.	0.	0.	36516.	40000.
34	0.	0.	0.	0.	0.	0.	0.	26742.	1538.	0.	28280.	40000.
35	0.	0.	4804.	0.	0.	0.	177.	0.	0.	0.	4981.	15000.
36	0.	0.	12770.	0.	3376.	842.	1917.	0.	0.	0.	18905.	20000.
37	609.	37.	6069.	0.	540.	421.	147.	0.	0.	0.	7823.	-0.
38	0.	0.	1680.	0.	0.	162.	593.	0.	0.	0.	2435.	15000.
39	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	15000.
40	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	15000.
41	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	15000.
42	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	15000.
43	0.	0.	0.	0.	0.	0.	0.	181.	0.	0.	181.	0.
44	0.	0.	0.	0.	0.	0.	0.	17403.	0.	0.	17403.	20000.
45	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	40000
46	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	40000
47	5153.	9678.	8334.	186.	2353.	5352.	2248.	0.	0.	0.	33304.	35000.
48	1212.	0.	1662.	328.	0.	0.	516.	936.	0.	21822.	26476.	150000.
49	0.	0.	957.	0.	0.	1331.	1710.	0.	510.	0.	4508.	100000.
50	0.	0.	110.	0.	0.	0.	278.	30444.	6424.	0.	37256.	50000.
51	0.	0.	0.	0.	0.	266.	6366.	0.	0.	0.	6632.	0.
52	8309.	327.	12946.	0.	0.	437.	915.	10858.	220.	0.	34020.	25000.
53	11324.	2102.	13123.	0.	306.	1166.	14.	23366.	237.	0.	51638.	130000.
54	0.	0.	2180.	20493.	0.	467.	27.	22265.	241.	0.	45673.	50000.
55	0.	6694.	1669.	184.	0.	4297.	494.	19902.	327.	0.	33567.	35000.
56	0.	0.	3384.	184.	0.	1153.	340.	20448.	236.	0.	25755.	40000.
57	0.	0.	906.	0.	0.	2584.	3431.	19581.	19287.	0.	44569.	40000.
58	0.	0.	47.	155.	0.	7568.	2699.	16080.	3372.	6270.	37019.	40000

59	0.	0.	9301.	0.	0.	8693.	0.	23425.	138.	0.	41557.	140000.
60	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
61	35000.	20000.	297.	0.	0.	0.	0.	0.	0.	0.	55297.	1000000.
62	0.	625.	31490.	390.	0.	339.	36145.	0.	413.	0.	69402.	150000.
63	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	10000.
64	0.	0.	3359.	0.	0.	1104.	16447.	0.	0.	0.	20910.	50000.
65	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	100000.
66	0.	0.	0.	0.	0.	0.	0.	28146.	0.	0.	28146.	50000.
67	0.	0.	458.	0.	0.	292.	996.	32767.	12457.	0.	46970.	50000.
68	0.	0.	0.	1898.	0.	337.	319.	15594.	0.	0.	18148.	50000.

ZONE	SQUARE FEET OF VACANT SPACE BY TYPE										ZONE TOTAL
	CLASS	LAB	OFFICE	STUDY	SPECIAL	GENERAL	SUPPORT	HOUSING	FOOD	ATHLETIC	
1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
12	0.	0.	20000.	0.	0.	0.	0.	0.	0.	0.	20000.
13	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
14	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
22	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
26	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
27	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
28	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
29	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
30	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
31	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
32	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
33	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
34	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
35	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
36	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
37	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
38	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
39	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
40	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
41	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
42	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
43	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
44	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
45	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
46	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
47	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
48	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
49	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
50	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
51	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
52	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

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**********************************************************
*****  MEASURE OF EFFECTIVENESS =  59.13659  *****
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PLAN 1
CYCLE 1
FUNDS AVAILABLE = $ 100000000.

ACTIVITY VALUES

1	HUM LECT	=	20209.
2	HUM LAB	=	7086.
3	HUM O/R	=	3934.
4	S S LCT	=	25451.
5	S S LAB	=	0.
6	S S O/R	=	3291.
7	SCI LCT	=	10340.
8	SCI LAB	=	11135.
9	SCI RSCH	=	2022.
10	SCI OFF	=	1014.
11	ENG LCT	=	1170.
12	ENG LAB	=	168.
13	ENG RSCH	=	629.
14	ENG OFF	=	300.
15	RESDENTL	=	300800.
16	STUDY	=	122474.
17	RECRTN 1	=	126105.
18	RECRTN 0	=	249344.
19	GEN ADMN	=	5500.
20	AUXLRY	=	3675.
21	PUBLIC	=	840.

PLAN 1
CYCLE 1

CRITICAL ACTIVITIES (UTILIZATION)

	ACTIVITY	CURRENT UTILIZATION	MAXIMUM UTILIZATION	MINIMUM UTILIZATION	PRIORITY INDEX	AREA FOR UMIN	AREA FOR UMAX
10	SCI OFF	4.200	1.000	.900	32.000	172696.	150717.
13	ENG RSCH	2.310	1.000	.350	2.015	1426.	334.
3	HUM O/R	1.104	1.000	.900	1.040	11801.	5415.
9	SCI RSCH	1.320	1.000	.500	.640	7490.	1461.
11	ENG LCT	1.312	1.000	.500	.625	12267.	2359.
6	S S O/R	1.045	1.000	.900	.450	8313.	2322.
1	HUM LECT	1.045	1.000	.500	.090	54355.	2265.

CRITICAL ACTIVITIES (NO SPACE)

ACTIVITY	ACTIVITY LEVEL	ASSIGNED SPACE	AREA FOR MINIMUM UTILIZATION	AREA FOR MAXIMUM UTILIZATION
NONE				

CRITICAL ACTIVITIES (SPACE CONDITION)

	ACTIVITY	ZONE	AREA
15	RESDENTL	57	18381.

CRITICAL ZONES (DENSITY)

ZONE	CURRENT AREA	ALLOWABLE AREA	EXCESS	ACTIVITY	ASSIGNED AREA
37	7823.	-0.	7823.		
				19 GEN ADMN	6310.
				20 AUXLRY	1513.
43	181.	0.	181.		
				19 GEN ADMN	181.
51	6632.	0.	6632.		
				19 GEN ADMN	6632.
52	34020.	25000.	9020.		
				1 HUM LECT	4011.
				3 HUM O/R	4517.
				4 S S LCT	4735.
				5 S S LAB	327.

					6 S S O/R	7455,	
					7 SCI LCT	451,	
					10 SCI OFF	363,	
					15 RESDENTL	11697,	
					19 GEN ADMN	464,	
	57	44589,	40000,	4589,			
					15 RESDENTL	44507,	
					19 GEN ADMN	82,	

PLAN 1
CYCLE 1
PROJECT 1

EARLIEST CYCLE = 1
LATEST CYCLE = 4

CYCLE CRITICAL

	ACTIVITY	ZONE	ACTION	QUANTITY	COST	LUMP SUM	TOTAL COST	UTILIZATION
64	15 RESDENTL	57	DESTROY	12287,	.00	12500,	12500,	1.036
	15 RESDENTL	57	DESTROY	18381,	.00	15000,	15000,	1.073
	19 GEN ADMN	57	DESTROY	82,	.00	25,	25,	.990
	13 ENG RSCH	16	BUILD	1400,	21.00	21000,	29400,	.356

PLAN 1
CYCLE 1
PROJECT 2

EARLIEST CYCLE = 2
LATEST CYCLE = 4

PROJECT 2 NOT CRITICAL, CYCLE NOT CRITICAL

PROJECT ACTIVITIES NOT CRITICAL

PLAN 1
CYCLE 1
PROJECT 3

EARLIEST CYCLE = 1
LATEST CYCLE = 4

CYCLE CRITICAL

	ACTIVITY	ZONE	ACTION	QUANTITY	COST	LUMP SUM	TOTAL COST	UTILIZATION
10	SCI OFF	13	BUILD	300000,	18,00	100000,	5400000,	,570
3	HUM D/R	12	ADD	8000,	5,00	1000,	41000,	,957
6	S S O/R	12	ADD	9000,	5,00	1500,	46500,	,890

PLAN 1
CYCLE 1
PROJECT 4

EARLIEST CYCLE = 2
LATEST CYCLE = 4

PROJECT 4 NOT CRITICAL, CYCLE NOT CRITICAL

PROJECT ACTIVITIES NOT CRITICAL

PLAN 1
CYCLE 1
PROJECT 5

EARLIEST CYCLE = 1
LATEST CYCLE = 1

CYCLE CRITICAL

	ACTIVITY	ZONE	ACTION	QUANTITY	COST	LUMP SUM	TOTAL COST	UTILIZATION
15	RESDENTL	25	IMPROVE	32767,	4,50	25000,	172451,	1,073

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***** MEASURE OF EFFECTIVENESS = 63.66871 *****

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FUNDS AVAILABLE $ 10000000.
CYCLE COST 5689351.

BALANCE 4310649.

MAINTENANCE COST REPORT FOR CYCLE 1

SPACE TYPE	QUANTITY	UNIT COST	COST
1	141143.	1.50	211714.
2	232644.	1.80	418759.
3	619328.	1.65	1021891.
4	76613.	1.50	114920.
5	14084.	2.00	28168.
6	105728.	1.70	179738.
7	148656.	1.65	245282.
8	445599.	2.05	913478.
9	109364.	1.50	164046.
10	98729.	1.50	148093.
		TOTAL COST	3446090.

CRITICAL ACTIVITIES (UTILIZATION)

ACTIVITY		CURRENT UTILIZATION	MAXIMUM UTILIZATION	MINIMUM UTILIZATION	PRIORITY INDEX	AREA FOR UMIN	AREA FOR UMAX
9	SCI RSCH	1.320	1.000	.500	.640	7490.	1461.
11	ENG LCT	1.312	1.000	.500	.625	12267.	2359.
15	RESDENTL	1.073	1.000	.750	.293	221925.	37668.
1	HUM LECT	1.045	1.000	.500	.090	54855.	2265.
10	SCI OFF	.570	1.000	.900	3.301	-127304.	-149283.
6	S S O/R	.890	1.000	.900	.102	-687.	-6678.

CRITICAL ACTIVITIES (NO SPACE)

ACTIVITY	ACTIVITY LEVEL	ASSIGNED SPACE	AREA FOR MINIMUM UTILIZATION	AREA FOR MAXIMUM UTILIZATION
NONE				

CRITICAL ACTIVITIES (SPACE CONDITION)

	ACTIVITY	ZONE	AREA
15	RESDENTL	57	-0.

CRITICAL ZONES (DENSITY)

ZONE	CURRENT AREA	ALLOWABLE AREA	EXCESS	ACTIVITY	ASSIGNED AREA
13	300000.	50000.	250000.		
				10 SCI OFF	300000.
37	7823.	-0.	7823.		
				19 GEN ADMN	6310.
				20 AUXLRY	1513.
43	181.	0.	181.		
				19 GEN ADMN	181.
51	6632.	0.	6632.		
				19 GEN ADMN	6632.
52	34020.	25000.	9020.		
				1 HUM LECT	4011.
				3 HUM O/R	4517.
				4 S S LCT	4735.
				5 S S LAB	327.
				6 S S O/R	7455.
				7 SCI LCT	451.
				10 SCI OFF	363.
				15 RESDENTL	11697.
				19 GEN ADMN	464.
57	82339.	40000.	42339.		
				15 RESDENTL	6839.

PLAN 1 SUMMARY

CYCLE	PROJECT 1	2	3	4	5
1	X	0	X	0	X
2	0	X	0	X	0
3	0	0	0	0	0

X = PROJECT EXECUTED
0 = PROJECT NOT EXECUTED

	ACTIVITY	MINIMUM UTILIZATION	MAXIMUM UTILIZATION	GROWTH RULE	ACTIVITY LEVEL	CURRENT UTILIZATION	TOTAL AREA
1	HUM LECT	.500	1.000	1	30314.	1.308	60326.
2	HUM LAB	.400	1.000	2	10629.	.825	33269.
3	HUM O/R	.900	1.000	3	6556.	1.595	60064.
4	S S LCT	.500	1.000	4	35632.	1.400	51646.
5	S S LAB	.400	1.000	5	0.	.000	19250.
6	S S, O/R	.900	1.000	6	4787.	1.294	60596.
7	SCI LCT	.500	1.000	7	16544.	1.000	49968.
8	SCI LAB	.400	1.000	8	17816.	.700	139457.
9	SCI RSCH	.500	1.000	9	2696.	1.760	4567.
10	SCI OFF	.900	1.000	10	1352.	.760	347099.
11	ENG LCT	.500	1.000	11	1281.	1.457	7549.
12	ENG LAB	.400	1.000	12	184.	.920	22458.
13	ENG RSCH	.350	1.000	13	744.	.421	1655.
14	ENG OFF	.900	1.000	14	335.	1.111	9313.
15	RESDENTL	.750	1.000	15	300800.	.870	635103.
16	STUDY	.850	1.000	16	183711.	1.485	69746.
17	RECRTN I	.850	1.000	17	132110.	.990	78664.
18	RECRTN O	.850	1.000	18	329134.	.000	0.
19	GEN ADMN	.850	1.000	19	7500.	1.138	318607.
20	AUXLRY	.500	1.000	20	4200.	.900	45247.
21	PUBLIC	.300	1.000	21	960.	.780	23604.

ZONE	SQUARE FEET ASSIGNED BY SPACE TYPE										ZONE TOTAL	ZONE MAX
	CLASS	LAB	OFFICE	STUDY	SPECIAL	GENERAL	SUPPORT	HOUSING	FOOD	ATHLETIC		
1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000.
2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000.
3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000.
4	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000.
5	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000.
6	12196.	30458.	19485.	4822.	0.	642.	13444.	0.	0.	0.	81047.	1000000.
7	4121.	94582.	22721.	5282.	366.	3770.	4733.	0.	0.	0.	135575.	1000000.
8	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1000000.
9	7088.	0.	12676.	32767.	0.	4677.	8939.	0.	0.	0.	66147.	1000000.
10	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000.
11	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	1000000.
12	1287.	0.	24843.	0.	927.	1072.	4984.	0.	186.	36870.	70169.	750000.
13	0.	0.	300000.	0.	0.	0.	0.	0.	0.	0.	300000.	50000.
14	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000.
15	0.	0.	296.	0.	0.	16337.	0.	0.	0.	0.	16633.	17000.
16	9630.	22658.	11687.	5998.	1655.	0.	4733.	0.	436.	0.	56799.	140000.
17	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
18	4950.	25496.	4526.	1800.	0.	0.	10274.	0.	0.	0.	47046.	60000.
19	13241.	1694.	36479.	2126.	3188.	2741.	2942.	0.	130.	0.	62541.	66000.
20	0.	0.	8828.	0.	401.	6608.	513.	0.	2095.	2277.	20722.	110000.
21	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000.
22	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	50000.
23	2171.	0.	1900.	0.	0.	183.	967.	279.	0.	31490.	36990.	100000.
24	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
25	0.	0.	0.	0.	0.	3515.	0.	32767.	178.	0.	36460.	50000.
26	0.	0.	0.	0.	0.	1766.	0.	13041.	0.	0.	14809.	15000.
27	0.	0.	6117.	0.	87.	14007.	7976.	50.	41264.	0.	69501.	125000.
28	0.	0.	1286.	0.	0.	8295.	0.	132767.	20000.	0.	162348.	250000.
29	0.	0.	0.	0.	0.	0.	0.	7801.	0.	0.	7801.	60000.
30	5572.	0.	28703.	0.	0.	403.	7532.	0.	172.	0.	42382.	115000.
31	14079.	0.	12985.	0.	489.	1062.	301.	0.	77.	0.	28993.	115000.
32	5201.	18293.	11159.	0.	396.	2625.	2983.	0.	127.	0.	40784.	125000.
33	0.	0.	91.	0.	0.	1110.	2548.	32767.	0.	0.	36516.	40000.
34	0.	0.	0.	0.	0.	0.	0.	26742.	1538.	0.	28280.	40000.
35	0.	0.	4804.	0.	0.	0.	177.	0.	0.	0.	4981.	15000.
36	0.	0.	12770.	0.	3376.	842.	1917.	0.	0.	0.	18905.	20000.
37	609.	37.	6069.	0.	540.	421.	147.	0.	0.	0.	7823.	-0.
38	0.	0.	1680.	0.	0.	162.	593.	0.	0.	0.	2435.	15000.
39	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	15000.
40	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	15000.
41	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	15000.
42	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	15000.
43	0.	0.	0.	0.	0.	0.	0.	181.	0.	0.	181.	0.
44	0.	0.	0.	0.	0.	0.	0.	17403.	0.	0.	17403.	20000.
45	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	40000.
46	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	40000.
47	5153.	9678.	8334.	186.	2353.	5352.	2248.	0.	0.	0.	33304.	35000.
48	1212.	0.	1662.	328.	0.	0.	516.	936.	0.	21822.	26476.	150000.
49	0.	0.	957.	0.	0.	1331.	1710.	0.	510.	0.	4508.	100000.
50	0.	0.	110.	0.	0.	0.	270.	30444.	6424.	0.	37256.	50000.
51	0.	0.	0.	0.	0.	266.	6366.	0.	0.	0.	6632.	-0.
52	8309.	327.	12946.	0.	0.	437.	915.	10858.	228.	0.	34020.	25000.
53	11324.	2102.	13123.	0.	306.	1166.	14.	23366.	237.	0.	51638.	130000.
54	0.	0.	2180.	20493.	0.	467.	27.	22265.	241.	0.	45673.	50000.
55	0.	6694.	1669.	184.	0.	4297.	494.	19902.	327.	0.	33567.	35000.
56	0.	0.	3384.	184.	0.	1153.	348.	20446.	236.	0.	25755.	40000.
57	0.	0.	906.	0.	0.	2066.	3451.	36762.	38574.	0.	82339.	40000.
58	10000.	0.	50047.	155.	0.	7588.	2699.	16088.	3372.	6270.	97019.	40000.

60	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
61	35000.	20000.	297.	0.	0.	0.	0.	0.	0.	0.	55297.	1000000.
62	0.	625.	31490.	390.	0.	339.	36145.	0.	413.	0.	69402.	150000.
63	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	10000.
64	0.	0.	3359.	0.	0.	1104.	16447.	0.	0.	0.	20910.	50000.
65	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	100000.
66	0.	0.	0.	0.	0.	0.	0.	28146.	0.	0.	28146.	50000.
67	0.	0.	456.	0.	0.	292.	996.	32767.	12457.	0.	46970.	50000.
68	0.	0.	0.	1898.	0.	337.	319.	15594.	0.	0.	18148.	50000.

ZONE	SQUARE FEET OF VACANT SPACE BY TYPE										ZONE TOTAL
	CLASS	LAB	OFFICE	STUDY	SPECIAL	GENERAL	SUPPORT	HOUSING	FOOD	ATHLETIC	
1	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
2	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
3	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
4	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
5	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
6	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
7	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
8	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
9	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
10	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
11	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
12	0.	0.	3000.	0.	0.	0.	0.	0.	0.	0.	0.
13	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	3000.
14	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
15	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
16	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
17	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
18	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
19	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
20	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
21	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
22	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
23	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
24	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
25	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
26	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
27	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
28	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
29	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
30	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
31	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
32	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
33	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
34	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
35	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
36	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
37	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
38	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
39	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
40	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
41	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
42	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
43	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
44	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
45	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
46	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
47	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
48	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
49	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
50	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
51	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
52	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

54	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
55	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
56	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
57	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
58	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
59	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
60	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
61	35000.	20000.	0.	0.	0.	0.	0.	0.	0.	55000.	0.
62	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
63	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
64	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
65	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
66	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
67	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
68	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.

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***** MEASURE OF EFFECTIVENESS = 63.11942 *****

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CRITICAL ACTIVITIES (UTILIZATION)

	ACTIVITY	CURRENT UTILIZATION	MAXIMUM UTILIZATION	MINIMUM UTILIZATION	PRIORITY INDEX	AREA FOR UMIN	AREA FOR UMAX
3	HUM O/R	1.595	1.000	.900	5.949	46378.	35734.
16	STUDY	1.485	1.000	.850	3.233	52104.	33827.
6	S S O/R	1.294	1.000	.900	2.942	26544.	17830.
9	SCI RSCH	1.760	1.000	.500	1.520	11509.	3471.
14	ENG OFF	1.111	1.000	.900	1.115	2189.	1038.
19	GEN ADMN	1.138	1.000	.850	.923	108134.	44123.
11	ENG LCT	1.437	1.000	.500	.875	14154.	3303.
4	S S LCT	1.400	1.000	.500	.800	92963.	20650.
1	HUM LECT	1.308	1.000	.500	.615	97446.	18560.
10	SCI OFF	.760	1.000	.900	1.401	-54039.	-83345.

CRITICAL ACTIVITIES (NO SPACE)

ACTIVITY	ACTIVITY LEVEL	ASSIGNED SPACE	AREA FOR MINIMUM UTILIZATION	AREA FOR MAXIMUM UTILIZATION
NONE				

CRITICAL ACTIVITIES (SPACE CONDITION)

ACTIVITY	ZONE	AREA
NONE		

CRITICAL ZONES (DENSITY)

ZONE	CURRENT AREA	ALLOWABLE AREA	EXCESS	ACTIVITY	ASSIGNED AREA

	13	300000.	50000.	250000.		
					10 SCI OFF	300000.
	37	7823.	-0.	7823.		
					19 GEN ADMN	6310.
					20 AUXLRY	1513.
	43	181.	0.	181.		
					19 GEN ADMN	181.
	51	6632.	0.	6632.		
					19 GEN ADMN	6632.
	52	34020.	25000.	9020.		
					1 HUM LECT	4011.
					3 HUM O/R	4517.
					4 S S LCT	4735.
					5 S S LAB	327.
					6 S S O/R	7455.
					7 SCI LCT	451.
					10 SCI OFF	363.
					15 RESDENTL	11697.
					19 GEN ADMN	464.
	57	82339.	40000.	42339.		
					15 RESDENTL	6839.
74	58	97019.	40000.	57019.		
					1 HUM LECT	10000.
					15 RESDENTL	26648.
					16 STUDY	155.
					19 GEN ADMN	59020.
					21 PUBLIC	1196.

THE FOLLOWING REPORT REFLECTS YEARLY BALANCES ASSUMING BUILDING COSTS ARE DISTRIBUTED OVER A THREE YEAR PERIOD

CYCLE...	1	ADJUSTED YEARLY BALANCE...	4310649.00
CYCLE...	2	ADJUSTED YEARLY BALANCE...	15210648.90
CYCLE...	3	ADJUSTED YEARLY BALANCE...	35210649.00

		CONSTRUCTION COSTS	RENOVATION COSTS	MAINTENANCE COSTS
CYCLE	1	5429400.	259951.	3446090.
CYCLE	2	4100000.	0.	3778590.
CYCLE	3	0.	0.	3778590.
TOTALS....		9529400.	259951.	11003269.

SUMMARY

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In the foregoing pages we have attempted to give the reader a description of the educational institution as an organism governed by the information it processes as much as by the will of its management. That is to say that even though the act of decision is reserved for humans, information must serve as the basis for decisions made about resource allocation. Unless there is an understanding of the nature and the uses of information in institutional management the purposes of the organization may be thwarted. By the same token, the timeliness and adequacy of this information can greatly improve the effectiveness of management planning. The space portion of planning for resource allocation has been our particular concern. We have concentrated on information needs in the two areas fundamental to the determination of facilities requirements: an inventory of space inside buildings, and observed patterns of space-using activities. From the point of view of the facilities planner, the processes the institution executes in pursuit of its objectives involve matching specific activities with appropriate space.

An approach to the collection and use of data on room space was described. Information on every room is generated in two basic types: physical characteristics and assignments. The correctness and currency of the latter is enhanced when room assignments to people, programs and *uses* become part of an official space plan, and are a source of management control.

In looking at patterns of space-using activities emphasis was given to the unscheduled variety. This was done because they tend to be difficult to identify and predict, and because few records are now kept on them, though they probably account for over 90% of the average institution's space services consumed. By taking a look at an entire 24-hour day through individual student *diaries*, a systematic view was obtained of the facilities (campus and non-campus) for different purposes by an important segment of the campus population.

And finally, a computer program for the evaluation of alternate building programs was described. Input data requirements were set forth and related to the activities and facilities data discussed earlier. While the evaluator program cannot hope to make decisions for institutional management, it can test alternative building programs for their effect on finances, levels of program operation, and the degree to which institutional goals can be met.

The material contained in the other three manuals generated by this project are intended to fill the need for more detailed information on the ideas and techniques developed.

APPENDIX

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Appendix: Procedures and data requirements for allocating space within the university and for new construction decisions

The following paragraphs are a straightforward application of economic theory to the problem of allocating space, and for determining when it is economic to build additional space rather than to attempt to use existing space more intensively. The development of ideas in this part is not constrained by any considerations of practicality. The final section, Steps Toward Implementation, attempts to develop procedures which roughly approximate the theoretical model and which can in fact be implemented in cost accounting, budget and space allocation procedures of the University.

The ultimate objective of this analysis is not solely to improve decision criteria for allocating or expanding space. It is, perhaps more importantly, an essential part of the process of deriving costs of various university programs. The most important university decisions have to do with which programs to undertake, and at what levels. Since space costs vary considerably from program to program, it is impossible to make porgram decisions with major cost implications for the University without including space cost information.

Theoretical considerations

Space in a university is an input which has a cost, though it is rarely treated as such. Space costs absorb resources which could be used for staff or in other ways. The University, insofar as its activities in constructing, owning, and operating buildings are concerned, may be thought of as a landlord providing space to each of its activities. It needs to develop criteria for allocating space among programs and for decision-making in acquiring more space via construction or purchase. In its role as a purveyor of education and research, the University decides whether or not to undertake various programs, at what levels, and how much in the way of funds it should allocate to each. The programs are judged upon their contribution to the achievement of the various goals of the University.[24] To the extent that it acts rationally, the University allocates budget funds in such a way that those programs which do more toward meeting its goals per dollar of cost are financed, and those which do less are not undertaken, or, being less urgent, are initiated only when additional budget funds become available.

Having decided which programs to undertake, and the volume of budget funds to be allocated to each, the University should *charge* each program (both in its cost accounting system and in the information given to decision-makers within each program — department heads, deans, etc.) all costs which can be directly attributed to it, including space used. In the process of budgeting, directors of programs should be free to substitute space, faculty, research assistants, materials, or

[24] The decision to undertake a program, incidentally, should be based on estimates of cost over a period of years including space costs.

any other inputs freely if through such substitution program objectives are better met. If less space is used, and space charges are accordingly reduced, the program, free to spend funds thus *saved* on salaries or equipment, may improve its effectiveness significantly. Program directors would thus automatically be brought into the University's resource allocation decisions, and would be required to weigh all elements of cost against each other, rather than dealing with a salaries and materials budget at one point in time, and negotiating (to them, costless) space needs with another set of university officers at another time.

The program planner, able to opt for cheaper or less space, may prefer to devote next year's funds to wages for one more person, using a lesser amount of space. In so doing, he is substituting people for space in pursuit of a better method of carrying out his program's mission.[25] On the other hand, if space expenditures are made through a separate *overhead* account and not budgeted or borne by the programs that benefit from them, space is costless and, in addition, not substitutable for other resources.

At the base of our research must lie the assumption that space is allocated rationally. That is, it is allocated as though there could be substitution among types of space as well as between space and other program resources. If a market pricing mechanism such as will be discussed below does not function in reality (and it does not now at Duke) it may be imperfectly approximated in the actions of the existing space-allocating authority; *imperfectly* because presumably the central authority knows much less about the effect of space on program output than the director of the program itself.

Cost elements in space

The basic elements of cost to the University in providing space are depreciation, interest on funds committed, and charges for repairs and maintenance.[26] Only the latter is a cash outlay year by year; the former two represent internal non-cash measures of cost. They are, nonetheless, real elements of cost. Indeed, the cash outlay for construction precedes in time the depreciation charges.

Depreciation on all space should be estimated on the basis of the replacement cost of equivalent facilities rather than on original cost. If the University is observed to be paying current prices for additional space of any particular kind, then the opportunity cost of using any existing space of that kind is the current replacement cost. If any activity presently using space is thought not to be worth its cost when space rent at replacement cost is included, then that activity should be abolished or reduced in scope, and the activities for which new space is being constructed put in its place (continuing the assumption of equivalent kinds of space).

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[25] In the language of economics, the program director seeks equality of marginal productivity of a dollar spent in the use of each resource. He thereby tends to maximize the total *product* obtainable from a given amount of budgeted funds. The product or output of his program is generally best measured by the director.

[26] Other costs, such as electricity, heat, water, and telephone service, can be charged directly to the using activity, and are not included in the discussion of space costs.

Interest should be charged at present rates of return on endowed funds, including capital gains. This is, at the margin, the cost of using funds for buildings rather than endowment. It is true that much construction is paid out of funds which could not be had for endowment. Nevertheless, it is transactions at the margin which set prices, and the University is observed by using up endowment funds. As long as it does so, the appropriate interest rate on funds invested in buildings is the investment income foregone.

With respect to accounting procedures for the above, all budgets would be increased by the amount of rent charged, which would appear as both (internal) income and expenditure to the university (rents to be charged on the basis described below). Offsetting rent income, there would be charges for depreciation, interest, and maintenance.[27] Maintenance would represent a cash outlay, as at present. Interest would appear as an item of both internal income and expense.

Depreciation would appear as an internal expense not offset by any internal or notational income. Indeed, it *is* such an expense since, as buildings depreciate, the University is gradually consuming some of its capital resources. Since it does not normally accumulate a replacement fund from current operations, it must look to the generosity of future donors.

Factors in pricing space

The optimum allocation of space is achieved when full use is made of it[28] and when the cost of the space used by a program just equals the value of the space to the program which uses it. Such conditions suggest a market in which goods are sold. Prices are set at levels which allow for everything to be sold. Buyers purchase only if the price is a fair measure of their desire for it. By *pricing* room space to users at a university and obliging user programs to budget for space expense, a market relationship is set up between the university as vendor and univeristy programs as buyers. The prices at which different types of space are offered should be set at a level sufficient to *clear the market,* i.e., to insure full use of space, but to leave no buyer unsatisfied, i.e., able and willing to pay the price but unable to find the space he wants. Once such a relationship is set in motion and a few budgeting periods have passed, prices should have been adjusted in response to varying user preferences reflected in requests for space at existing prices. Space types in *short supply* will subsequently have to bear relatively high prices in order to avoid leaving a group of potential users dissatisfied. Space of a less popular type will command relatively lower prices in order to attract enough programs to it to ensure its full use. In this way preferences for specific space types are revealed by the buyers to the sellers.

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[27] The three elements of cost should be claculated so that their annual sum remains constant throughout the useful life of the facility, as long as the quality of service provided by the facility is expected to remain roughly constant. That is, interest charges will be relatively small. As the remaining undepreciated value of the facility diminishes, interest charges fall and depreciation charges rise.

[28] Subject to the possibility, mentioned below, that the costs of cramming every minute of every room with some activity or other may exceed the costs of more space, hence requiring some *slack capacity.*

Rents charged to activities, therefore, need not necessarily equal costs of space use; the differences may be used in determining whether proposed additions to space are economical. All space utilized in the University may be classified into a few categories, some of which are interchangeable with little or no expense, some with remodeling expense, and some of which are not at all interchangeable. Each activity (department, program, etc.) has space for its exclusive use, and space which it shares with other activities. The former category includes all highly specialized space, and some space such as ordinary classrooms or offices which could in principle be used by other activities. It should be a policy objective of the University to minimize exclusively held space; the space pricing mechanism can be used to encourage this result.

For exclusively held space, all rent is charged to the using activity. For shared space, the using activity is charged only for the time actually used — for instance, by the hour. Hourly rates should not be the same for all space, even when it has the same characteristics. This is a peak load problem and a location problem. Some times are thought to be more desirable than others. For classes, MWF 9:20-12:30 seems to be highly preferred. Therefore, hourly charges should be higher at popular times and lower at less popular times. The same reasoning applies to location. Some areas are thought to be more desirable than others. These areas should command higher rents.

Hourly rental charges for each type of shared space have been set with *right* levels when there is no unfilled demand for any space. If, for example, some departments are still seeking to schedule more MWF classes on West Campus than can be accommodated there, the rents for classrooms at that time and place should be raised. If, after careful adjustment of all charges according to time and location, there is some unused space at some time, then the University has, in a sense, too much space of the unused kind.

Incidentally, it is not suggested here that each room should be used 24 hours per day; it is suggested rather that some practical maximum (say 8 am to 10 pm) be established for each kind of space, and that lack of use within those hours indicates, in a sense, too much space.

We should note that the use of the pricing mechanism for space allocation is a substitute, and eventual replacement of the existing administrative rationing of space.

When (as at Duke now) space is not charged to the program or department which uses it but rather to an unrelated overhead account, any program is subsidized by the University to the degree that it is space-using. In such a situation, space is artificially rationed by an administrative center of authority which must make such allocative decisions internally with little reference to relative space costs or types required by different programs, or to the magnitude of benefits more space may bring to certain programs in comparison to others. If space were internally *priced* so as to reflect the costs of its use, consuming programs themselves would be obliged to weigh the value of having more space at their disposal against the value to be had from other available resources.

The pricing mechanism, of course, would never completely displace administrative discretion. In one sense, it greatly strengthens the role of

administrative action at a higher level – the total budget allocation to each activity or program. Further, in any given year, relative prices for different types of shared space will not completely *clear the market.* There will still be some administrative rationing of space for which demand exceeds supply, but this will be a small fraction of the present 100% administrative allocation.

Criteria for new construction

A further guide to the existence of *too much* or *too little* of each kind of space may be found in comparing rent charged for a particular unit of space (room, wing, building) with the cost. If rent income exceeds cost, there is too little of this kind of space and more should be built. If, on the other hand, annual rent income falls below annual oeprating cost, there is too much of this type of space, even though it may be largely or even fully utilized by lowering charges sufficiently. Needless to say, investment in such a building is a *sunk cost*, and its use should be continued even at a loss. Management is careful, however, not to compound the mistake by building more such space. Management, moreover, does not force departments to pay rates high enough to *cover* costs. Programs should not be burdened with costs which result from past management errors.

The same considerations suggest criteria for having on hand *excess capacity* which may actually be optimal. The rate structure for each kind of space (as to time and place) which is necessary to eliminate the excess demand at each time and for each location provides clues. Suppose that *prime time* at a particular place on a campus is so popular that rents are three or four times higher than at other times or places. There must, then, be real benefits to departments in scheduling classes at these hours, else they could not be willing to sacrifice salaries, secretaries, etc., to do so. These benefits should be recognized as real, whatever they are. Buildings might generate enough *rent* to cover their costs even with some idle hours. If so, they should be constructed, even with *excess* capacity. If departments or other program managers confronted with costs still value convenience so highly, so should the University.

It is more likely to be the case that rather modest rate differentials will spread out facilities usage, so that this situation will probably not arise.

Criteria for remodeling

There may be some cases in which some kinds of space are *excessive* (i.e., idle at certain times or places, or do not generate enough revenue to cover these costs). Other kinds of space are *short* (i.e., requests for such space exceed available space so that prices are raised, and when prices are raised, rent revenues exceed costs). It may further be the case that some of the *excess* space can be converted into *short* space by remodeling, rather than by construction of new space. If the rent which could be received from the remodeled space less rent presently being received, if any, (bearing in mind that rent may fall as remodeling increases the supply of this kind of space) exceeds or equals the annual cost of the remodeled space, then it is economical to remodel. Note that the annual cost to be compared with the difference in rents includes only interest and depreciation on the remodeling outlay, since the relatively low rent being charged on the *excessive* space already

measures all of the costs of the original building which can be recovered (i.e., the opportunity costs).

Dynamic aspects

One must bear in mind that the University's activities are likely to grow over time. Existing programs will change in size (many will grow; some, hopefully, will shrink or disappear) and new programs will appear. Space needs may change. Space which has been excessive may become scarce, and vise versa. Changes in teaching methods or curriculum may change space needs. These considerations do not affect the pricing decisions within each time period. Year by year scarce facilities (scarce in relation to that year's demands) should have high prices and plentiful ones low prices.

The decisions which are affected by long-run changes are the decisions to construct or remodel. That is, the criteria stated previously, looking only at the current year's rents and costs, were too simple. One must, rather, estimate rents and costs period by period over the expected life of the facility. Another situation thus may exist in which space capacity becomes economic: if the expected rate of increase in construction costs exceeds the rate of interest, it may be economic to build ahead of expected demands.

Flexibility in space design

The future is full of uncertainties; projections and predictions inevitably will be wrong in greater or lesser degrees. Therefore, new space should be flexible in conversion whenever possible (remodeled at relatively low cost; see Criteria for Remodeling above) and flexible in use in its initial state. The wider the variety of potential program applications a resource unit (say, a room) may have, the more it can be shared, the more intensive its use, and the smaller the cost of the stock of space required per unit of output. On the other hand, to the extent that particular programs require specialized space, inflexibility, and consequently inability to substitute, must be created. The opportunity costs of building space which will accommodate only a few activities may be high. This is another way of saying that the money, had it been put into flexible rooms, might have yielded a lower cost per unit of output through higher utilization, or that $1 of specialized space must have an anticipated output of significantly greater value than $1 spent on flexible space (or indeed any resource) in order to be justified.

Steps toward implementation

The first step is a rough weighing of the costs and benefits of a space accounting and allocation system itself. Conceivably, it may not be worth the trouble. The major elements of system costs are salaries and computer time. The chief benefit is the prevention of *unnecessary* building. The annual monetary benefit is equal the interest, depreciation, and maintenance saved. With respect to buildings that would have been built with outside funds not otherwise available, the annual saving is in maintenance cost only.

Should it be thought feasible to proceed with a space cost and allocation system, the University

should proceed on the assumption that it has roughly the *right* amount of space for existing programs (i.e., that rents charged will roughly cover costs). This assumption will no doubt have to be revised on the basis of the first year's experience, but it is a convenient starting point. All existing space, room by room, should be coded into a small number (five or six) of categories for calculating replacement cost, and three or four categories as to expected useful life. Each room should be coded as to whether it is used exclusively by an activity or program, or is shared. There must be, in due time, a careful identification and separation of university programs. Since that has not yet been done, existing budget classifications should be used in this interim. As a beginning step, any department, school, or other unit for which a budget is now prepared and which has an identifiable center of responsibility should be treated as a *program* or an *activity*. For exclusively used space, rent should be charged wholly to the using activity. For shared space, rents should be tentatively set at levels which will, on the average, cover costs, based on present usage levels. All space should be coded into two or three categories with respect to desirability of location. The tentative rental charge for the most desirable space should command a small premium over cost – say 10% for trial purposes. For shared space (primarily classrooms and lecture halls) there should be an additional premium (say 20% of cost) during *prime time.* A rental charge per unit of time, probably a class hour, should be developed for all shared space. This charge should be based on the present average utilization experience, so that cost will be roughly covered in the first trial run.

There should then be developed a tentative charge for each budget activity, composed of an annual charge for all exclusively held space, and an hourly charge for estimated use of the shared space, reflecting time and location premia. The program could be initiated during summer, using the fall schedule and the previous spring's schedule (the latter as an estimate for the following spring) as a basis for charging for use of shared space. Department budget would then be increased by the sum of rent with which they were being charged. Fall rent should then be charged on the basis of exclusive space, and shared space as scheduled. Rent income would be credited, to offset the higher operating budgets on the University's books. Spring rent would be charged on the basis of exclusive space, and the actual spring schedule. Each University official with responsibility for any activity's budget should be presented with a detailed statement of space used, and the charge for each unit of space. He should also be presented with a list of all unused and underutilized space (shared space with less than average usage). All of this space should be offered for the following year at a discount, say cost less 10%.

In preparing his budget requests for the following year, each person with budget responsibility for an activity should determine his space requests on the basis of tentatively set prices. Possibly, some exclusively held space would be released, and some space offered at a discount would be requested. Fall schedules would have to be prepared at the same time, so that fall room requests based on the prevailing set of prices would be known. The persons (or committees) handling room scheduling would then tally room requests against availabilities. Excess demands at particular times and places would serve as the basis for raising prices the following year, and continued underutilization of space would indicate that those prices should be lowered.

88 The budget preparation time during the first year of space charges is a particularly crucial time. Departments and other activities will have just been charged for space for the first time, their budgets having been increased to meet the charges. They will be confronted with prices for space for the following year and, for the first time, will be in a position to weigh space needs against other uses of funds. The University must strictly honor its commitment to permit activities to save money on space and spend the money for other purposes. Activities which pare their space usage must not simply have their budgets cut. The University must protect itself that year, and throughout the three- or four-year period when space charges are being adjusted, against the possibility of a drastic decrease in space use (for which costs are largely sunk) and a drastic increase in salaries and other cash outlays. Extreme changes are not likely, but some substitution is quite likely indeed. Any input which has heretofore been free, and now bears a price, is likely to be used more sparingly. During the crucial first year, it might be advisable to allow for a much smaller than normal increase in each activity's budget, in anticipation of some shift away from rent toward other (cash-using) inputs.

Procedure

Purposes

- To improve program cost data in University accounting systems, and to improve estimates of costs of new programs, by including charges for space use.
- To decentralize space allocation decisions from a central space administrator to directors of various University programs.
- To force program directors to weigh space inputs along with other inputs in their programs, by charging them for all inputs. This procedure amounts to decentralizing the weighing of various alternative inputs; a decision now generally made at a centralized point in the University administration. (See "Procedures and Data Requirements for Allocating Space Within the University and for New Construction Decisions" for a more detailed discussion.)

Initial Required Procedures

The following outlined procedures are to be undertaken simultaneously by the indicated offices of the University and include program identification, gathering data on existing space as to characteristics and uses, development of replacement cost data, and design of space cost accounting system.

- Program Identification (by The Academic Administration)
  - Essential in any event for the successful installation of program budgeting.
  - Does not correspond to existing budget categories, or existing Department/School/College divisions. A given discipline (Department) may house several *programs.* Examples: an undergraduate major, service to other departments, graduate instruction, and possibly individual, specialized programs within these activities which should be separated for cost purposes. The chief criterion for separability is whether other programs could be conducted in the absence of this particular set of activities.

- As a starting point, use existing budget entities, but separate graduate and undergraduate in Arts and Sciences.
  - Primary programs (directly conduct teaching, research, and closely related activities).
    - Existing academic departments
    - Existing graduate and professional schools
    - The Hospital
    - The University Press
  - Other primary programs (directly produce *end products* rather than serve other programs).
    - Inter-collegiate athletics
    - The Placement Office
    - The Chapel and religious activities
    - Cultural activities — concerts, exhibits, lectures
  - Supporting programs (the costs of which will, in some cases, be allocated to primary programs).
    - General Academic Administration
    - Business Management (excluding maintenance and operation of buildings, which are charged as space costs)
    - Library
    - Auxiliary enterprises
- Measuring existing space, and establishing routines for maintaining current records. (Space records section of Business Office. See Volume 2, Room Inventory.)
  - Note that the basic unit is the *room* coded by *building*. The latter is the basic unit for accumulating most categories of costs, except for areas of buildings which have significantly different construction and maintenance costs.
  - Identify each space by current user, if reserved exclusively for him. Develop system for recording changes in exclusive user, as part of space assignment and change recording system.
  - Update records by new construction, demolition, and physical alterations.
- Develop original and replacement cost data for each building, and for segments of it, if costs differ significantly. Develop appropriate depreciation rates and patterns for each building (Accounting Department).
- Develop procedures for charging non-capitalized repairs, maintenance, routine services, electric power, and heat to each building. Use existing work order system, refine as necessary (Accounting Department).
- Note that the above four procedures occur simultaneously.

First-year Rent Charges

First-year rent charges, room by room, are based on cost per year per square foot, as modified below.

- Charge rent based on cost:
  - Auxiliary enterprises
  - Central libraries
  - Athletic association
  - Highly specialized (single-use) space
- Space held for exclusive use of programs, but with possible alternative uses:

- ▫Base on cost, but set prices with premia for especially desirable locations.
- ▫Note that prices must subsequently be adjusted: upward if other programs still want some of the space; downward if existing space is not requested by any program director.
- ▫On first round, estimate premia or discount that will *clear the market,* but be prepared to change them.

- For space shared by different programs during time periods (day, week).
  - ▫Develop rents per hour, or other convenient time units.
  - ▫Base on cost, but adjust up or down for particularly desirable *times* and *places.*
  - ▫ Calculate existing average hourly usage, assume this to be the norm for setting cost per hour, though average usage will probably rise with the institution of non-zero, differential prices.

Current Use

Advise program directors of space they are now using, exclusively or shared, and advise them of prospective prices, to be charged in their regular budgets.

- Let them request space for the following term. For space with duplicate requests, raise prices; for unrequested space, lower prices. Recirculate directors with new prices. Use only one iteration the first year.
- Raise their budgets by total space charges, *and permit them to substitute other resources for space foregone.*
- Year of introduction should have enough budgetary slack to permit shift of program dollars from space (previously costless) to other inputs, such as salaries and materials.

Future Use

- In succeeding years, raise or lower prices until remaining duplicate requests and unused space are eliminated.
- Use total program costs, including space charges, in total resource allocation decisions.
- Use price-cost relationships as criteria for new construction decisions, or alterations. Note that, for a given building or type of space, revenue greater than cost (depreciation, interest, maintenance) indicates a need for new space. Revenue less than cost indicates the existence of *too much* space relative to other inputs desired by program directors.
- Note that space charges will appear as both revenues (to the University) and expenditures (in budgets of various programs) in exactly offsetting amounts.